U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-273 105

Agricultural Runoff Management (ARM) Model Version II Refinement and Testing

Hydrocomp, Inc, Palo Alto, Calif

Prepared for

Environmental Research Lab, Athens, Ga

Aug 77

EPA-600/3-77-098
August 1977

PB 273 105

Ecological Research Series

[illegible]

[illegible]

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the ECOLOGICAL RESEARCH series. This series describes research on the effects of pollution on humans, plant and animal species, and materials. Problems are assessed for their long- and short-term influences. Investigations include formation, transport, and pathway studies to determine the fate of pollutants and their effects. This work provides the technical basis for setting standards to minimize undesirable changes in living organisms in the aquatic, terrestrial, and atmospheric environments.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/3-77-098

2.

3. RECIPIENT'S ACCESSION NO.
PB273105

4. TITLE AND SUBTITLE
Agricultural Runoff Management (ARM) Model
Version II: Refinement and Testing

5. REPORT DATE
August 1977 issuing date

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
A.S. Donigian, Jr.; D.C. Beyerlein; H.H. Davis, Jr.; and N.H. Crawford

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Hydrocomp, Incorporated
Palo Alto, CA 94304

10. PROGRAM ELEMENT NO.
1HB617

11. CONTRACT/GRANT NO.
R803772-01

12. SPONSORING AGENCY NAME AND ADDRESS
Environmental Research Laboratory - Athens, GA
Office of Research and Development
U.S. Environmental Protection Agency
Athens, GA 30605

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE
EPA/600/01

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Agricultural Runoff Management (ARM) Model has been refined and tested on small agricultural watersheds in Georgia and Michigan. The ARM Model simulates the hydrologic, sediment production, pesticide, and nutrient processes on the land surface and in the soil profile that determine the quantity and quality of agricultural runoff. This report discusses the research and model refinements related to soil moisture and temperature simulation, pesticide degradations, nutrient transformations and plant nutrient uptake. The goal is to evaluate and improve the pesticide and nutrient simulation capabilities of the ARM Model. However, the runoff and sediment modeling is also analyzed since these are the critical transport mechanisms of agricultural chemicals.

In general, comparison of simulated and recorded values indicates that the ARM Model can represent the major processes affecting agricultural runoff and can be a useful tool for planning and analysis. However, discrepancies do exist and point out the need for more testing and research in specific areas.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Simulation Runoff Water quality Planning Land use	Nonpoint pollution Model studies	02A 02B 08H 08M 13B 20D 68D

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 312
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE A14 - A01

EPA Form 2220-1 (9-73)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1977-757-056/6551 Region No. 5-11

EPA-600/3-77-098
August 1977

AGRICULTURAL RUNOFF MANAGEMENT (ARM) MODEL VERSION II: REFINEMENT AND TESTING

by

Anthony S. Donigian, Jr.
Douglas C. Beyerlein
Harley H. Davis, Jr.
Norman H. Crawford

Hydrocomp, Incorporated
Palo Alto, California 94304

Research Grant No. R803772-01

Project Officer

Lee A. Mulkey
Technology Development and
Applications Branch
Environmental Research Laboratory
Athens, Georgia 30605

ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
ATHENS, GEORGIA 30605

DISCLAIMER

This report has been reviewed by the Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, GA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

As environmental controls become more costly to implement and the penalties of judgment errors become more severe, environmental quality management requires more efficient analytical tools based on greater knowledge of the environmental phenomena to be managed. As part of this Laboratory's research on the occurrence, movement, transformation, impact, and control of environmental contaminants, the Technology Development and Applications Branch develops management or engineering tools to help pollution control officials achieve water quality goals through watershed management.

Refinement and testing of the Agricultural Runoff Management (ARM) Model represents a continuing effort to develop mathematical tools for analyzing and managing agricultural nonpoint pollution. Although more testing and research in specific areas is needed, the application of the model on small agriculture watersheds in Georgia and Michigan indicates that the ARM Model can represent the major environmental factors affecting agriculture runoff and can be a useful tool for planning and analysis.

David W. Duttweiler
Director
Environmental Research Laboratory
Athens, Georgia

ABSTRACT

The Agricultural Runoff Management (ARM) Model has been refined and tested on small agricultural watersheds in Georgia and Michigan. The ARM Model simulates the hydrologic, sediment production, pesticide, and nutrient processes on the land surface and in the soil profile that determine the quantity and quality of agricultural runoff. This report discusses the research and model refinements related to soil moisture and temperature simulation, pesticide degradations, nutrient transformations and plant nutrient uptake. The goal is to evaluate and improve the pesticide and nutrient simulation capabilities of the ARM Model. However, the runoff and sediment modeling is also analyzed since these are the critical transport mechanisms of agricultural chemicals.

Small agricultural watersheds in Watkinsville, Georgia and East Lansing, Michigan, instrumented for continuous monitoring and sampling of runoff, provided data for model testing. In general, comparison of simulated and recorded values indicate that the ARM Model can represent the major processes affecting agricultural runoff, and can be a useful tool for planning and analysis. However, discrepancies do exist and point out the need for more testing and research in specific areas.

Runoff and sediment simulation results are good except following tillage operations. The relationship of agricultural practices to the model runoff and sediment parameters needs to be studied and quantified. Pesticide and nutrient runoff simulations are fair to good when runoff and sediment are accurately represented. Sediment-associated pesticide and nutrient forms are usually better simulated than soluble or solution forms. Pesticides that move both on sediment and in solution remain a problem, indicating the need to further investigate the partitioning mechanism. Pesticide degradation can be adequately represented by a step-wise first-order mechanism if soil pesticide measurements are available; predictive pesticide degradation and attenuation models are needed. Soil nutrient transformations are reasonably simulated with the first-order reactions assumed in the nutrient model. Although simulation of the sediment-associated nutrients in runoff is good, the solution forms, such as nitrate, are not adequately represented. These solution forms are highly sensitive to the simulated interflow component of runoff; thus the soil moisture profile and the separate runoff components need to be more accurately defined to improve the nutrient runoff simulation.

In general, the soil processes occurring in the near surface soil zone exert the major influence on agricultural runoff from small agricultural watersheds and should be further investigated. Recommendations are included for (1) further testing of the ARM Model, (2) investigation of the

algorithm deficiencies noted above, and (3) modifications to promote and simplify use of the ARM Model by the potential user community.

This report was submitted as partial fulfillment of Research Grant No. R803722-01 by Hydrocomp, Incorporated under the sponsorship of the Environmental Protection Agency. The work was completed as of April 1977.

CONTENTS

Abstract iv
Figures viii
Tables xiv
Abbreviations and Symbols xv
Acknowledgments xvi

1. Introduction. 1
2. Conclusions. 3
3. Recommendations 6
4. The Agricultural Runoff Management (ARM) Model: Present Status 9
5. Data Collection and Analysis Programs 19
6. Soil Environment Simulation 25
7. Soil Pesticide Degradation Simulation 53
8. Soil Nutrient Simulation. 63
9. Runoff and Sediment Simulation Results. 83
10. Pesticide Runoff Simulation Results 97
11. Nutrient Runoff Simulation Results. 109

References 130

Appendices

A. ARM Model Input Description: Version II dated 6/10/77. . . . 133
B. P2 watershed storm event simulation results 150
C. P6 watershed storm event simulation results 161
D. ARM Model Source Code: Version II dated 6/10/77. 174

Preceding page blank

FIGURES

4.1 ARM Model structure and operation 10
4.2 Model soil layers for pesticide and nutrient storage. 11
4.3 Pesticide and nutrient movement in the ARM Model. 14
4.4 Pesticide adsorption/desorption algorithms. 16
4.5 Nutrient transformations in the ARM Model 17

5.1 P2 watershed, Watkinsville, Georgia 20
5.2 P6 watershed, East Lansing, Michigan. 21

6.1 Lands simulation. 26
6.2 Comparison of soil moisture and UZS/UZSN at Watkinsville, 1973. 28
6.3 Soil moisture at 5 cm depth at Watkinsville, 1973 29
6.4 Comparison of soil moisture and LZS/LZSN at Watkinsville, 1973. 30
6.5 Soil moisture at 40 cm depth at Watkinsville, 1973. 31
6.6 Variability of UZFM with UZF. 36
6.7 Surface zone temperature simulation at Watkinsville, 1973 . . . 38
6.8 Upper zone temperature simulation at Watkinsville, 1973 40
6.9 Surface zone maximum and minimum daily temperature simulation at Watkinsville, 1973 42
6.10 Upper zone maximum and minimum daily temperature simulation at Watkinsville, 1975 43
6.11 Upper zone temperature simulation at East Lansing, 1974 44
6.12 Upper zone temperature simulation at East Lansing, 1975 47
6.13 Watkinsville soil temperature at 60 cm depth, 1973. 50
6.14 East Lansing soil temperature at 60 cm depth, January 1973 - November 1974. 51

7.1 Comparison of atrazine degradation rates for the P2 watershed. 54
7.2 Environmental effects on diphenamid degradation rates 55
7.3 Environmental approach sensitivity trials 57
7.4 Atrazine in soil storage on the P2 watershed. 59
7.5 Paraquat in soil storage on the P2 watershed, 1974-1975 60
7.6 Atrazine and paraquat soil storages on the P6 watershed, 1974-1975 62

8.1 Comparison of plant uptake functions. 69
8.2 NO_3 and TKN in surface and upper zone storage on the P2 watershed. 75
8.3 NO_3 and TKN in lower zone storage on the P2 watershed 76
8.4 PO_4 and Organic P in upper zone storage on the P2 watershed . . 77

8.5 NO_3 and Available P in surface and upper zone storage on the P6 watershed 78
8.6 NH_4 and Organic N in surface and upper zone storage on the P6 watershed 79
8.7 Simulated crop nutrient uptake from the P2 and P6 watersheds 81

9.1 Monthly runoff and sediment loss from the P2 watershed. 87
9.2 Runoff and sediment loss from the P2 watershed for the storm of May 28, 1973 89
9.3 Runoff and sediment loss from the P2 watershed for the storm of May 24, 1974 90
9.4 Runoff and sediment loss from the P2 watershed for the storm of June 11, 1975. 91
9.5 Monthly runoff and sediment loss from the P6 watershed. 93
9.6 Runoff and sediment loss from the P6 watershed for the storm of April 18, 1975 94
9.7 Runoff and sediment loss from the P6 watershed for the storm of August 20, 1975. 95

10.1 Monthly pesticide removal for the P2 watershed. 98
10.2 Monthly pesticide removal for the P6 watershed. 101
10.3 Paraquat removal from the P2 watershed for the storm of May 28, 1973 104
10.4 Atrazine removal on sediment from the P2 watershed for the storm of May 28, 1973 104
10.5 Atrazine removal in solution from the P2 watershed for the storm of May 28, 1973 105
10.6 Atrazine removal in solution from the P2 watershed for the storms of June 27 and July 27, 1974 105
10.7 Atrazine in soil storage by zone on the P2 watershed. 106

11.1 Monthly Total Nitrogen and Phosphorus runoff from the P2 watershed. 114
11.2 Monthly Total Nitrogen and Phosphorus runoff from the P6 watershed. 115
11.3 Monthly Organic N and NH_4 on sediment from the P2 and P6 watersheds 117
11.4 Monthly NH_4, NO_3, and Organic N removal in solution from the P2 and P6 watersheds 119
11.5 Monthly Total PO_4 removal in solution from the P2 and P6 watersheds 121
11.6 TKN removal on sediment from the P2 watershed for the storm of June 11, 1975 122
11.7 NH_4 removal on sediment from the P2 watershed for the storm of June 11, 1975. 122
11.8 Total P removal on sediment from the P2 watershed for the storm of June 11, 1975. 123
11.9 NO_3 removal in solution from the P2 watershed for the storm of June 11, 1975. 123
11.10 NH_4 removal in solution from the P2 watershed for the storm of June 11, 1975. 124

11.11 PO_4 removal in solution from the P2 watershed for the storm of June 11, 1975. 124
11.12 Total N removal on sediment from the P6 watershed for the storm of August 27, 1974. 125
11.13 NH_4 removal on sediment from the P6 watershed for the storm of August 27, 1974. 125
11.14 Available P removal on sediment from the P6 watershed for the storm of August 27, 1974. 126
11.15 Total N removal in solution from the P6 watershed for the storm of August 27, 1974. 126
11.16 NO_3 removal in solution from the P6 watershed for the storm of August 27, 1974. 127
11.17 NH_4 removal in solution from the P6 watershed for the storm of August 27, 1974. 127

APPENDIX B

FIGURES

B1 Runoff and sediment loss from the P2 watershed for the storm of June 27, 1974 151
B2 Paraquat removal on sediment from the P2 watershed for the storm of June 27, 1974 151
B3 Atrazine removal in solution from the P2 watershed for the storm of June 27, 1974 152
B4 Atrazine removal on sediment from the P2 watershed for the storm of June 27, 1974 152
B5 TKN removal on sediment from the P2 watershed for the storm of June 27, 1974 153
B6 NH_4 removal on sediment from the P2 watershed for the storm of June 27, 1974 153
B7 Total P removal on sediment from the P2 watershed for the storm of June 27, 1974 154
B8 NO_3 removal in solution from the P2 watershed for the storm of June 27, 1974 154
B9 NH_4 removal in solution from the P2 watershed for the storm of June 27, 1974 155
B10 PO_4 removal in solution from the P2 watershed for the storm of June 27, 1974 155
B11 Runoff and sediment loss from the P2 watershed for the storm of July 24, 1975 156
B12 Paraquat removal on sediment from the P2 watershed for the storm of July 24, 1975 156
B13 Atrazine removal in solution from the P2 watershed for the storm of July 24, 1975 157
B14 TKN removal on sediment from the P2 watershed for the storm of July 24, 1975 157
B15 NH_4 removal on sediment from the P2 watershed for the storm of July 24, 1975 158
B16 Total P removal on sediment from the P2 watershed for the storm of July 24, 1974 158
B17 NO_3 removal in solution from the P2 watershed for the storm of July 24, 1975 159
B18 NH_4 removal in solution from the P2 watershed for the storm of July 24, 1975 159
B19 PO_4 removal in solution from the P2 watershed for the storm of July 24, 1975 160

APPENDIX C

FIGURES

C1 Runoff and sediment loss from the P6 watershed for the storm of August 27, 1974 162
C2 Runoff and sediment loss from the P6 watershed for the storm of August 13, 1974 162
C3 Paraquat removal on sediment from the P6 watershed for the storm of August 13, 1974 163
C4 Atrazine removal in solution from the P6 watershed for the storm of August 13, 1974 163
C5 Atrazine removal on sediment from the P6 watershed for the storm of August 13, 1974 164
C6 Total N removal on sediment from the P6 watershed for the storm of August 13, 1974 164
C7 NH_4 removal on sediment from the P6 watershed for the storm of August 13, 1974 165
C8 Available P removal on sediment from the P6 watershed for the storm of August 13, 1974 165
C9 Total N removal in solution from the P6 watershed for the storm of August 13, 1974 166
C10 NO_3 removal in solution from the P6 watershed for the storm of August 13, 1974 166
C11 NH_4 removal in solution from the P6 watershed for the storm of August 13, 1974 167
C12 PO_4 removal in solution from the P6 watershed for the storm of August 13, 1974 167
C13 Paraquat removal on sediment from the P6 watershed for the storm of August 20, 1975 168
C14 Atrazine removal in solution from the P6 watershed for the storm of August 20, 1975 168
C15 Atrazine removal on sediment from the P6 watershed for the storm of August 20, 1975 169
C16 Total N removal in sediment from the P6 watershed for the storm of August 20, 1975 169
C17 NH_4 removal on sediment from the P6 watershed for the storm of August 20, 1975 170
C18 Available P removal on sediment from the P6 watershed for the storm of August 20, 1975 170
C19 Total P removal on sediment from the P6 watershed for the storm of August 20, 1975 171
C20 Total N removal in solution from the P6 watershed for the storm of August 20, 1975 171

C21 NO_3 removal in solution from the P6 watershed for the storm of August 20, 1975 172
C22 NH_4 removal in solution from the P6 watershed for the storm of August 20, 1975 172
C23 PO_4 removal in solution from the P6 watershed for the storm of August 20, 1975 173

TABLES

4.1 ARM Model Components 12

5.1 Watersheds for ARM Model Testing 22
5.2 Cropping and Chemical Applications for the Test Watersheds (1973-1975) 23

6.1 Lower Zone Average Monthly Soil Temperatures for the Test Areas 52

8.1 Definition of N and P Reaction Rates 65
8.2 Coupled System of Differential Equations for Nitrogen Transformations 66
8.3 Fraction of Maximum Monthly Plant Uptake of Nutrients Used in the ARM Model for the P2 and P6 Watersheds 71
8.4 Nutrient Reaction Rates for the P2 and P6 Watersheds 72
8.5 N and P Fertilizer Applications. 74
8.6 Initial Soil Storages and Bulk Densities 74

9.1 Input Parameters for the P2 and P6 Watersheds. 84

10.1 Pesticide Runoff Simulation Results for the P2 Watershed 99
10.2 Pesticide Runoff Simulation Results for the P6 Watershed 102
10.3 Pesticide Parameter Values 107
10.4 Pesticide Applications 107

11.1 Nutrient Runoff Simulation Results for the P2 Watershed. 110
11.2 Nutrient Runoff Simulation Rusults for the P6 Watershed. 112

LIST OF SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS

cm	--centimeters
cms	—cubic meters per second
gm/ha	—grams per hectare
gm/l	—grams per liter
gm/min	—grams per minute
ha	—hectare
kg/ha	—kilograms per hectare
kg/min	--kilograms per minute
m	—meters
mg/l	—milligrams per liter
mg/min	—milligrams per minute
mm	—millimeters
ppm	—parts per million

SYMBOLS

N	—nitrogen
NH_4	—ammonium
NH_4-N	—nitrogen in the ammonium form
NO_2	—nitrite
NO_3	—nitrate
NO_3-N	—nitrogen in the nitrate form
P	—phosphorus
PO_4	—phosphate or orthophosphorus
PO_4-P	—phosphorus in the phosphate form
TKN	—total Kjeldahl nitrogen, i.e. organic nitrogen and ammonia nitrogen

ACKNOWLEDGMENTS

Many individuals have contributed to the research work performed in this project. Mr. Lee A. Mulkey of the EPA Environmental Research Laboratory in Athens, Georgia (ERL-Athens) provided overall coordination with ERL-Athens and valuable assistance in his capacity as project officer. Mr. David M. Cline and his staff in the Computer Operations branch of ERL-Athens ably assisted our work effort by supplying the necessary test data for both the Georgia and Michigan watersheds. Mr. Charles Smith, also of ERL-Athens, was a valuable source of information on the analysis and interpretation of the watershed data.

Dr. Ralph Leonard, from the USDA Southern Piedmont Conservation Research Center, and Drs. Boyd G. Ellis and Earl Erickson, from Michigan State University, provided critical insight into the behavior and response of the test watersheds. Their readiness to supply data and patience in responding to our numerous requests is greatly appreciated. The staff members of all the above supporting organizations are too numerous to mention without omission; their assistance is sincerely acknowledged.

At Hydrocomp a research team was organized to conduct the work in this project. Dr. Norman H. Crawford, as principal investigator, provided general direction and coordination. The research team was comprised of Anthony Donigian, Douglas Beyerlein, and Harley Davis. Mr. Donigian, as project manager, supervised and reviewed the project work and the final report. Mr. Beyerlein, as associate project manager, directed data preparation and management, software modifications, and pesticide simulation work. Mr. Davis conducted the nutrient model research refinements, calibration, and testing. All team members participated in the hydrology and sediment simulation work. Mr. Guy Funabiki provided graphical and drafting expertise, while Ms. Nancy Sharpe and Ms. Donna Mitchell supplied clerical assistance and support. The final report was typed by Ms. Kathy Francies and edited by Ms. Mitchell.

SECTION 1

INTRODUCTION

Since 1972 the Environmental Research Laboratory in Athens, Georgia (ERL-Athens) has sponsored the development and testing of mathematical models to simulate the quantity and quality of agricultural runoff. The overall goal of the program is to provide state-of-the-art models as tools for analyzing agricultural nonpoint pollution and evaluating the impact and effectiveness of alternative land management procedures. This report is the third in a series of research reports describing the development and testing of the Agricultural Runoff Management (ARM) Model, one of the tools whose development is being sponsored by ERL-Athens.

The initial effort in the ARM Model work produced the Pesticide Transport and Runoff (PTR) Model published in December 1973 (Crawford and Donigian, 1973). The PTR Model includes erosion, pesticide adsorption/desorption, and pesticide attenuation (volatilization and degradation) models interfaced with a pre-existing hydrologic model. Testing of the PTR Model was limited due to data availability. As a result of including snow accumulation and melt routines and developing plant nutrient simulation models, the PTR Model was renamed the ARM Model to reflect the wider scope of application. The ARM Model report (Donigian and Crawford, 1976), describes the model components, includes a brief user manual, and presents initial test results for runoff, sediment, and pesticide simulations for one year of data on two small watersheds in Georgia.

The inital test results and the availability of additional data from Watersheds in Georgia and Michigan provided the impetus for additional testing, evaluation, and refinement of the ARM Model simulation capabilities. Also, the nutrient model had not been tested with observed data prior to publication of the ARM Model report. Accordingly, the work described herein concentrates on evaluating and improving the pesticide and nutrient simulations of the ARM Model. Modeling runoff, sediment, and soil environmental factors (i.e. temperature and moisture) is also discussed in terms of their impact on pesticide and nutrient simulation.

Following the major conclusions and recommendations presented in Sections 2 and 3, respectively, the present status of the ARM Model is summarized in Section 4, emphasizing the significant changes from the version presented in the ARM Model report. The reader should refer to that report for a more complete description of the model components as that material will not be repeated here. Section 5 briefly describes the data collection programs and test watersheds in Georgia and Michigan. Section 6 discusses the simulation of soil moisture and temperature while pesticide degradation and soil nutrient transformations and corresponding simulation results are provided in Sections 7 and 8, respectively. Sections 9 through 11 present the simulation results for runoff and sediment (Section 9), pesticide content in runoff (Section 10), and nutrient content in runoff (Section 11). The appendices include an update of the input sequence and parameter list, detailed storm event simulation results, and the ARM Model source code (Version II dated 06/10/77).

SECTION 2

CONCLUSIONS

(1) The Agricultural Runoff Management (ARM) Model can represent runoff, sediment, pesticide, and nutrient processes on small agricultural watersheds in Georgia and Michigan. Model testing has shown that the major soil and transport mechanisms that determine the quantity and quality of agricultural runoff can be simulated with the ARM Model.

(2) The hydrologic portion of the ARM Model simulates soil moisture storages and all runoff components. The runoff simulation methodology has been tested and verified on numerous watersheds of all sizes in many geographical areas. However, the representation of the soil moisture profile may be too approximate for detailed simulation of the vertical movement and distribution of agricultural chemicals.

(3) Model testing has shown that the loss of solution phase chemicals, such as nitrates and soluble pesticides, from small watersheds is highly sensitive to the simulated interflow component of runoff. Thus, the assumptions and calibration of interflow characteristics must be evaluated in light of the resulting transport of solution chemicals.

(4) The method of snowmelt simulation in the ARM Model, based on energy-balance calculations, adequately represents the snow accumulation and melt process and the resulting runoff volumes. However, snowmelt hydrographs are not accurately simulated and the impact of frozen ground conditions is not represented. This is likely due to both inaccurate or insufficient meteorologic data and inadequacies in the snowmelt algorithms.

(5) In general, the ARM Model simulation of sediment production on the test watersheds is good when runoff hydrographs and monthly volumes are well simulated. The only exceptions to this are related to the effects of winter freeze/thaw conditions on sediment production and the occurrence of soil detachment and scour by overland flow. These conditions are not currently simulated in the model.

(6) Tillage operations have a major impact on the runoff and sediment producing characteristics of small agricultural watersheds. The ARM Model attempts to evaluate the impact of tillage on sediment production but does not consider the effect on runoff. Consequently storms immediately following tillage operations are not as accurately

simulated for runoff or the resulting sediment loss as storms occurring later in the growing season.

(7) The accuracy of the pesticide and nutrient simulations with the ARM Model is usually a direct function of the accuracy of the runoff and sediment simulation. Although some discrepancies exist, when runoff and sediment are adequately simulated the pesticide and nutrient simulated runoff values closely approximate the observed data.

(8) The adsorbed or sediment-associated forms of both pesticides and nutrients are better simulated with the ARM Model than the corresponding soluble or solution forms. The sediment-associated chemicals, such as adsorbed pesticides, organic nitrogen, and organic phosphorus are more stable and less affected by transformations than the soluble forms like nitrates, phosphates, and soluble pesticides.

(9) The pesticide simulation results indicate that:

  (a) Comparison of the single-valued (SV) and nonsingle-valued (NSV) adsorption/desorption functions for partitioning pesticides between the adsorbed and solution phases is inconclusive. The SV function is better for some storms while the NSV function is better for others. The observed tendency of the ratio of adsorbed to solution forms to increase during a growing season is better represented by the NSV function, but it is not clear that this observed behavior is due to an adsorption/desorption mechanism.

  (b) Processes that degrade and attenuate pesticides have a major impact on the amount of remaining pesticide available for runoff. Simulation of the aggregate impact of these processes can be reasonably performed by a step-wise first-order degradation approach using different rates following application and later in the growing season. The present state-of-the-art cannot provide a general method for representing the individual degradation mechanisms and the impact of environmental conditions.

(10) The nutrient simulation results indicate that:

  (a) The nutrient algorithms can simulate with good accuracy soil nutrient storages and transformations for the summer growing seasons on the test watersheds. For the nonsummer periods, the simulated soil temperatures obtained by regression with air temperature were not applicable, and adequate observed soil nutrient data was not available for comparison. However, the simulated soil nutrient storages behaved in a reasonable fashion throughout an 18-month simulation period.

  (b) Initial test results indicate that the accuracy of the simulation of nutrient runoff is limited more by the accuracy of the simulated transport mechanisms than the soil nutrient storages. Specifically, better definition of the interflow runoff component and vertical moisture movement would significantly improve the nutrient runoff simulation.

(c) Plant uptake of soluble nutrient forms, especially nitrate and phosphate, is a major mechanism controlling the availability of these forms for runoff and vertical leaching. Accurately simulating the time-dependent behavior of plant uptake, in relation to crop growth and fertilizer applications, is critical to evaluating the impact of agricultural operations on nutrient contributions to streams and groundwater.

SECTION 3

RECOMMENDATIONS

(1) Further testing of all portions of the ARM Model is needed to demonstrate the capabilities of the model and to delineate and confirm topics for future research. Past testing has shown that the model can represent the mechanisms determining the quantity and quality of agricultural runoff in two different climatic and geographical regions. Testing in other areas is needed to strengthen confidence in the model and demonstrate its general applicability.

(2) Model testing on larger watersheds, in the general range of 50 to 500 hectares, is needed to evaluate the model's representation of processes in the lower soil zones and chemical contributions to groundwater. In this way, simulation of the movement of soluble chemicals through subsurface pathways to a stream or waterbody can be investigated.

(3) The impact of tillage operations on runoff and sediment production should be quantified and incorporated into the ARM Model. This is especially important because the first events following pesticide and fertilizer applications are the most significant for agricultural chemical runoff.

(4) The relationship of different agricultural land management practices to the ARM Model parameters should be investigated and quantified if the model is to be used to evaluate methods of controlling agricultural nonpoint pollution. The extent to which specific practices can or cannot be simulated with the ARM Model, and the corresponding changes in model parameters needs to be delineated. Such work will likely produce additional recommendations for model modifications to accommodate agricultural practices common to different regions of the country.

(5) Future testing of the pesticide and nutrient simulation algorithms should evaluate the extent to which laboratory measurements and literature values of model parameters can be used to simulate pesticide and nutrient runoff without calibration on recorded data. Although the model algorithms have been designed to use commonly measured values, calibration of parameters has been used to evaluate the pesticide and nutrient algorithms after initial parameter values had been obtained from the literature. General use of the ARM Model will be severely limited if each application requires calibration of certain pesticide and nutrient parameters on recorded data.

(6) To improve the reliability and accuracy of the ARM Model the following recommendations are extended:

(a) Better definition of moisture, temperature, and chemical behavior in the surface soil layer (e.g. 0-1 cm) is needed since the processes in this zone directly affect the quality of surface runoff.

(b) In conjunction with (a), more accurate representation of the entire soil profile and intermediate moisture tranfers is required for detailed simulation of vertical chemical movement.

(c) Refinement of the erosion algorithms should concentrate on inclusion of detachment and scour by overland flow, consideration of gully erosion, and erosion simulation as a function of particle size. This work could significantly improve the sediment simulation and help to interface the ARM Model output with in-stream sediment transport models.

(d) If particle size erosion is added to the ARM Model, the pesticide and nutrient algorithms for sediment related processes should be re-evaluated to incorporate the dependence on particle size.

(e) Predictive models are needed for pesticide attenuation processes such as chemical, photochemical, and biological degradation and volatilization. Ideally, such models should consider the impact of soil environmental conditions (e.g. moisture, temperature, oxygen), be capable of application in various regions of the country, and utilize parameters easily measured in a laboratory.

(f) Evaluation and quantification of the impact of moisture and oxygen conditions on the soil nutrient reaction rates is needed. If this impact is significant, relationships should be developed and added to the ARM Model nutrient algorithms.

(g) Additional nutrient processes such as nitrogen fixation, ammonia uptake by plants, and the impact of nutrient contributions in precipitation, should be evaluated for their effect and possible inclusion in the model.

(7) To promote the general use of the ARM Model for investigation, evaluation, and management of agricultural runoff, the following topics should be considered:

(a) Guidelines for parameter evaluation, calibration, and analysis of simulation results are needed to assist the user in model application. This is especially lacking for the pesticide and nutrient parameters, and may require research to evaluate adsorption parameters, nutrient reaction rates, and nutrient uptake by various crops under field conditions.

(b) Simplification of the model structure and reduction in computer run time would provide a more user-oriented method of application. Some sacrifice in model accuracy would be justified if this resulted in less user effort in input preparation, parameter evaluation, and calibration.

(c) User workshops and assistance programs should be developed to attract and initiate potential model users. Some technical background and training is necessary for effective use of the ARM Model. Also, the establishment of the model on a central, nation wide computer network would then make the model available to users across the country without the need for separate source codes for each user. This would considerably simplify model updates and technology transfer with advances in the state-of-the-art.

(d) Extensive or repeated model use and model testing require an effective data management system to manipulate and analyze recorded and simulated data series. Analysis of the ARM Model output on a frequency or probability basis with such a data management system is necessary to effectively utilize the information provided by the continuous simulation of the ARM Model. Moreover, such a system is needed to incorporate nonpoint source analysis and simulation in general simulation models for evaluating comprehensive watershed management.

SECTION 4

THE AGRICULTURAL RUNOFF MANAGEMENT (ARM) MODEL: PRESENT STATUS

This section provides an overall description of the ARM Model and brief discussions of the present versions of the major component programs. The emphasis will be on the significant changes to the component programs that occurred in this study. The reader is referred to the ARM Model report (Donigian and Crawford, 1976) for details of the simulation algorithms.

THE MODEL

The ARM Model simulates runoff (including snow accumulation and melt), sediment, pesticides, and nutrient contributions to stream channels from both surface and subsurface sources. No channel routing procedures are included. Thus, the model is applicable to watersheds that are small enough that channel processes and transformations can be assumed negligible. Although the limiting area will vary with climatic and topographic characteristics, watersheds greater than two to five square kilometers are approaching the upper limit of applicability of the ARM Model.

Figure 4.1 demonstrates the general structure and operation of the ARM Model. The major components of the model individually simulate the hydrologic response (LANDS) of the watershed, sediment production (SEDT), pesticide adsorption/desorption (ADSRB), pesticide degradation (DEGRAD), and nutrient transformations (NUTRNT). The executive routine, MAIN, controls the overall execution of the program; calling subroutines at proper intervals, tranferring information between routines, and performing the necessary input and output functions. Table 4.1 describes the functions of each of the ARM Model components.

In order to simulate vertical movement and transformations of pesticides and nutrients in the soil profile, specific soil zones (and depths) are established so that the total soil mass in each zone can be specified. Total soil mass is a necessary ingredient in the pesticide adsorption/desorption reactions and nutrient transformations. Figure 4.2 depicts the zones and depths, assumed in the ARM Model. The depths of the surface and upper soil zones are specified by the model input parameters, SZDPTH and UZDPTH, with values of two to six millimeters and five to 20 centimeters, respectively. The upper zone depth corresponds to the depth of mixing of soil-incorporated chemicals. It also indicates the depth used to calculate the mass of soil in the upper zone whether agricultural chemicals are soil-incorporated or surface-applied. The lower zone depth of 1.83 meters has proved satisfactory in testing to date.

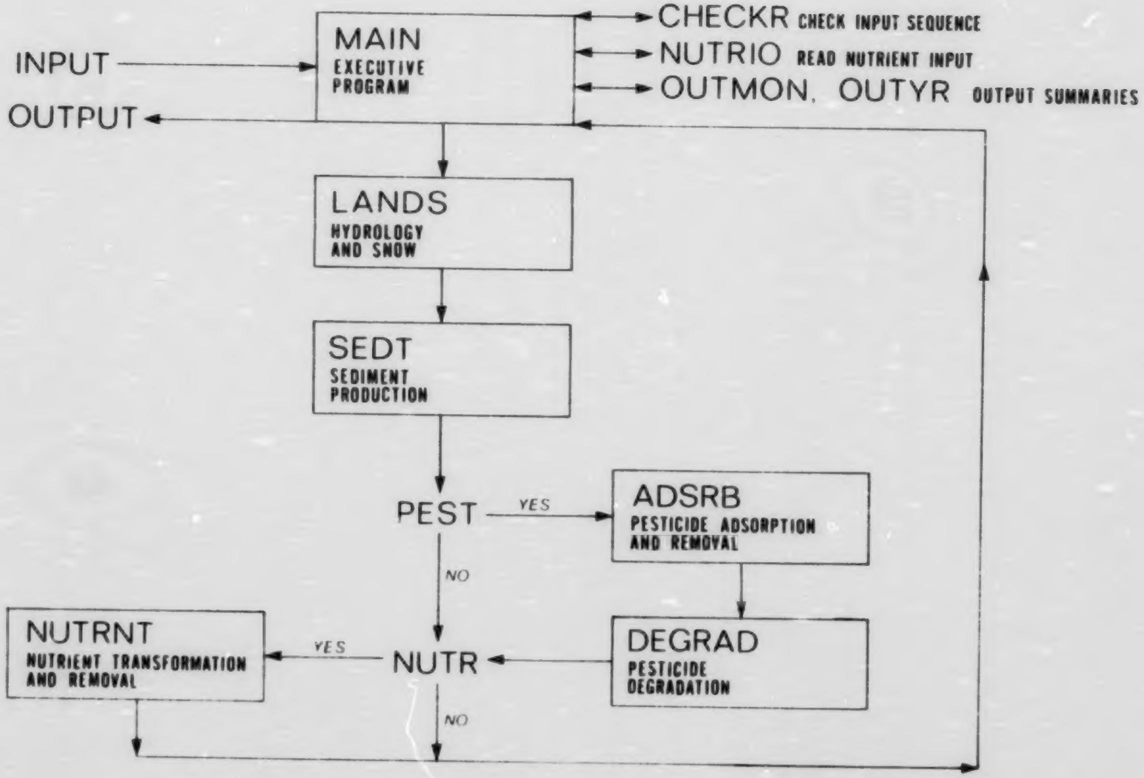

MAIN
EXECUTIVE PROGRAM
INPUT
OUTPUT
CHECKR CHECK INPUT SEQUENCE
NUTRIO READ NUTRIENT INPUT
OUTMON, OUTYR OUTPUT SUMMARIES
LANDS
HYDROLOGY AND SNOW
SEDT
SEDIMENT PRODUCTION
PEST
YES
ADSRB
PESTICIDE ADSORPTION AND REMOVAL
NO
DEGRAD
PESTICIDE DEGRADATION
NUTR
YES
NUTRNT
NUTRIENT TRANSFORMATION AND REMOVAL
NO

Figure 4.1 ARM model structure and operation

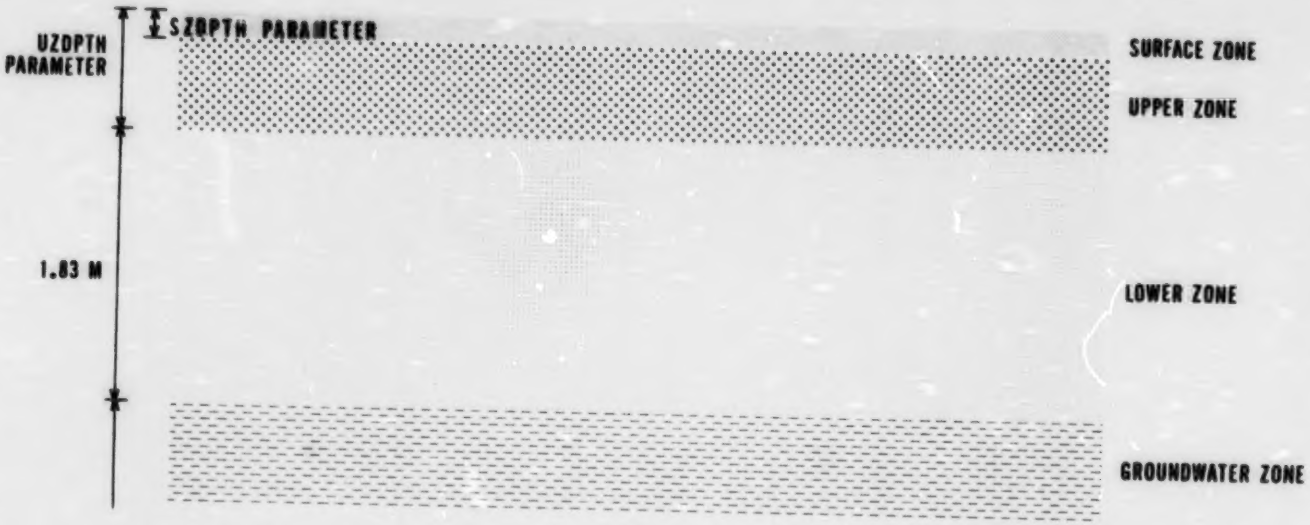

UZDPTH PARAMETER
SZDPTH PARAMETER
1.83 M
SURFACE ZONE
UPPER ZONE
LOWER ZONE
GROUNDWATER ZONE

Figure 4.2 Model soil layers for pesticide and nutrient storage

TABLE 4.1 ARM MODEL COMPONENTS

Major Program	Component Subroutine	Function
MAIN		Master program and executive control routine
	CHECKR	Checks input parameter errors
	CHECKS	Checks input parameter errors
	BLOCK DATA	Data initialization for common variables
	NUTRIO	Reads and checks nutrient input data
	OUTMON	Prints monthly output summaries
	OUTYR	Prints yearly output summaries
LANDS		Performs hydrologic simulation and snowmelt calculations
SEDT		Performs erosion simulation
	ERDBUG	Outputs to the printer erosion files written to disk for error checking
ADSRB		Performs pesticide soil adsorption/desorption simulation
	DSPTN	Performs desorption calculations
DEGRAD		Performs pesticide degradation simulation
NUTRNT		Performs nutrient simulation
	TRANS	Performs nutrient transformations

The transport and vertical movement of pesticides and nutrients, as conceived in the ARM Model, is indicated in Figure 4.3. Pollutant contributions to the stream can occur from the surface zone, the upper zone, and the groundwater zone. Surface runoff is the major transport mechanism carrying dissolved chemicals, pesticide particles, sediment, and adsorbed chemicals. The interflow component of runoff can transport dissolved pesticides or nutrients occurring in the upper zone. Vertical chemical movement between the soil zones is the result of infiltrating and percolating water. From the surface, upper, and lower zones, uptake and transformation of nutrients and degradation of pesticides is allowed. On the watersheds tested, the groundwater zone has been considered a sink for deep percolating chemicals since the groundwater flow contribution has been negligible. However, on larger watersheds this contribution could be significant.

MODEL COMPONENTS

The ARM Model simulates the major processes of importance in agricultural runoff with the following components:

LANDS

The LANDS program simulates all flow components (surface runoff, interflow, groundwater flow) and soil moisture storages by representing the processes of interception, infiltration, overland flow, percolation, evapotranspiration, and snow accumulation and melt. LANDS is basically an accounting procedure for moisture above, at, and beneath the soil surface. It is a modification of the Stanford Watershed Model (Crawford and Linsley, 1966) and the Hydrocomp Simulation Program (Hydrocomp, Inc., 1976). Snow calculations are based on an energy balance approach derived from work by the Corps of Engineers (1965), Anderson and Crawford (1964), and Anderson (1968). The LANDS program used in this study is identical to the previous version (Donigian and Crawford, 1976) except the evapotranspiration index input parameter, K3, can vary on a monthly basis. Since K3 represents the areal density of actively transpiring vegetation, this change allows a better representation of the evapotranspiration opportunity on agricultural watersheds (Johanson and Crawford, 1976).

SEDT

The SEDT program simulates the erosion processes of soil particle detachment by rainfall and transport by overland flow; overland flow values are transferred from the LANDS program. Input parameters allow the user to specify seasonal variations in land cover and the occurrence and impact of tillage operations. The only modification to the SEDT program algorithms performed during this study was the addition of a user-input soil compaction factor (SCMPAC). This factor reduces the amount of detached soil particles available for transport. It is basically a first-order decrease of the surface storage of soil fines performed on a daily basis during nonstorm periods. The SCMPAC parameter attempts to represent the natural aggregation and mutual attraction of soil particles and the compaction of the surface soil zone from which erosion occurs. These processes are a complex function

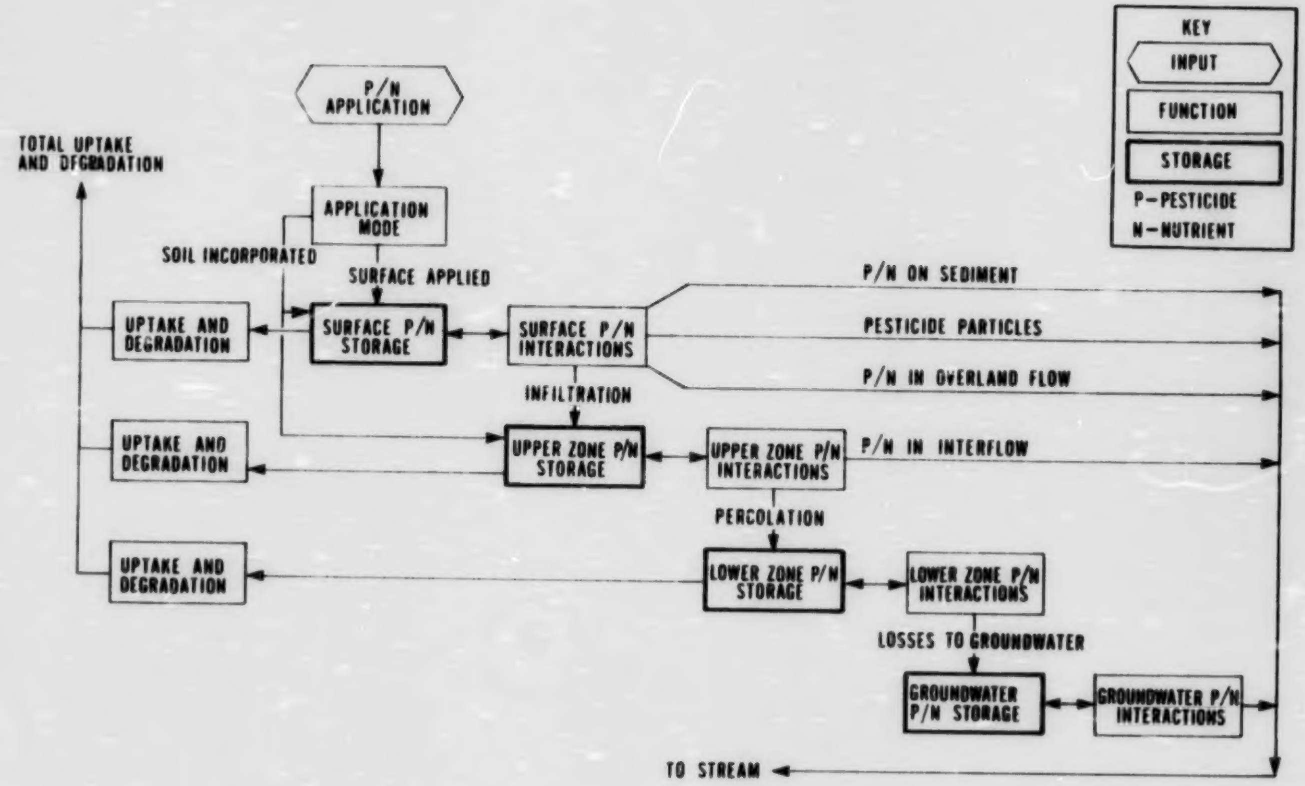

KEY
INPUT
FUNCTION
STORAGE
P-PESTICIDE
N-NUTRIENT
P/N APPLICATION
APPLICATION MODE
SOIL INCORPORATED
SURFACE APPLIED
TOTAL UPTAKE AND DEGRADATION
UPTAKE AND DEGRADATION
SURFACE P/N STORAGE
SURFACE P/N INTERACTIONS
P/N ON SEDIMENT
PESTICIDE PARTICLES
P/N IN OVERLAND FLOW
INFILTRATION
UPTAKE AND DEGRADATION
UPPER ZONE P/N STORAGE
UPPER ZONE P/N INTERACTIONS
P/N IN INTERFLOW
PERCOLATION
UPTAKE AND DEGRADATION
LOWER ZONE P/N STORAGE
LOWER ZONE P/N INTERACTIONS
LOSSES TO GROUNDWATER
GROUNDWATER P/N STORAGE
GROUNDWATER P/N INTERACTIONS
TO STREAM

Figure 4.3 Pesticide (P) and nutrient (N) movement in the ARM model

of soil characteristics, meteorologic conditions, and tillage practices for which a detailed simulation is beyond the scope of this study. Further research is needed to quantify the critical compaction mechanisms before simulation algorithms can be developed.

ADSRB

The ADSRB program in conjunction with the DSPTN subroutine simulates the adsorption/desorption processes of pesticides in the soil profile. The algorithms are identical to those discussed in the ARM Model report. The user can choose to employ either single-valued, reversible (Figure 4.4a) or nonsingle-valued, irreversible (Figure 4.4b) adsorption/desorption equations. Testing results of these options are discussed in Sections 9 and 10. The ARM Model has been modified to accept initial pesticide storage and multiple pesticide applications; the necessary input changes are included in Appendix A.

DEGRAD

The DEGRAD program calculates the attenuation and degradation of applied pesticide compounds. Since degradation is the most critical mechanism determining the amount of pesticide available for runoff, a major portion of the current work concentrated on the evaluation of alternative degradation algorithms. The following methods were considered:

(a) Daily first-order degradation.
(b) First-order degradation adjusted for soil moisture and temperature effects.
(c) Step-wise first-order daily degradation.

The present version of the DEGRAD program includes method (c), above, whereby different first-order rates are applied separately to specific time periods after pesticide application. Section 7 discusses each of the above methods and presents tests results.

NUTRNT

The NUTRNT program in conjunction with the TRANS subroutine simulates the nitrogen and phosphorus components of runoff and nutrient transformations in the soil profile. First-order mechanisms are used in all the transformations shown in Figure 4.5. The major changes in the nutrient algorithms during this study are:

(a) Eliminating NO_2 as a separate component and combining NO_2 and NO_3 into one component. Thus the previous K2 and KK2 reaction rates between NO_2 and NO_3 were eliminated.
(b) Eliminating the transformation path between adsorbed NH_4 and the NO_2/NO_3 combination.
(c) Including a regression equation for estimating soil temperature and then adjusting transformation rates for soil temperature changes.
(d) Allowing the user to specify a monthly variation in nutrient

Figure 4.4a Single-valued adsorption/desorption algorithm

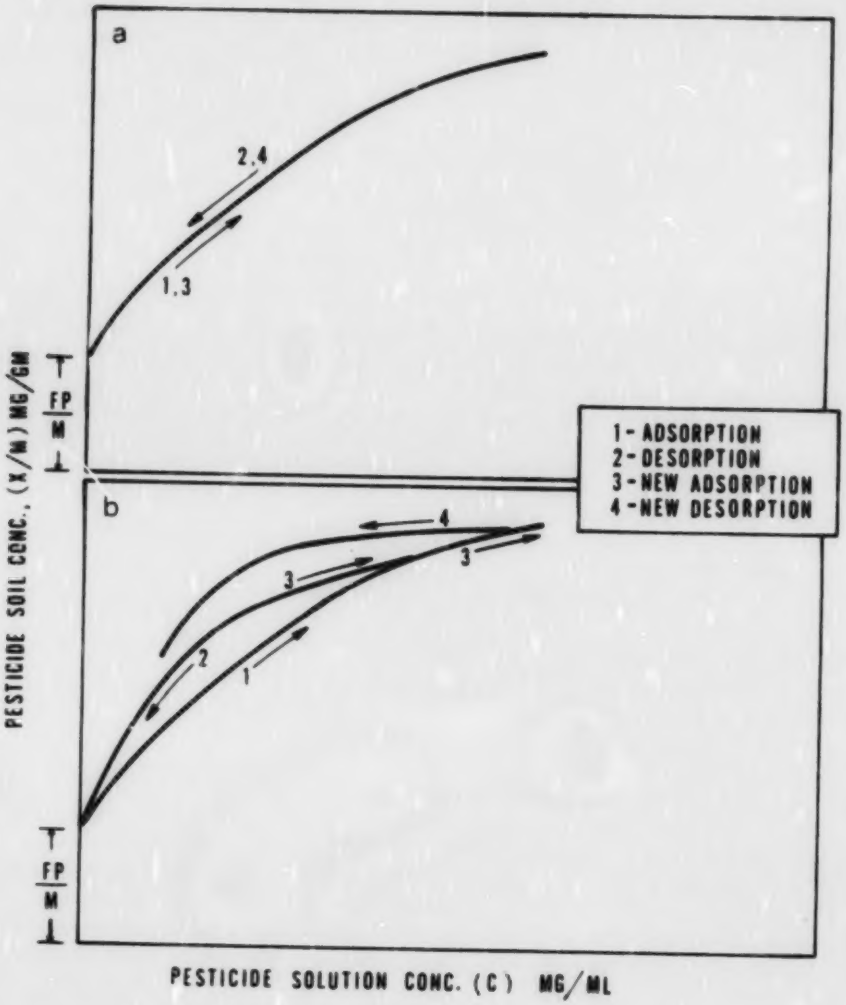
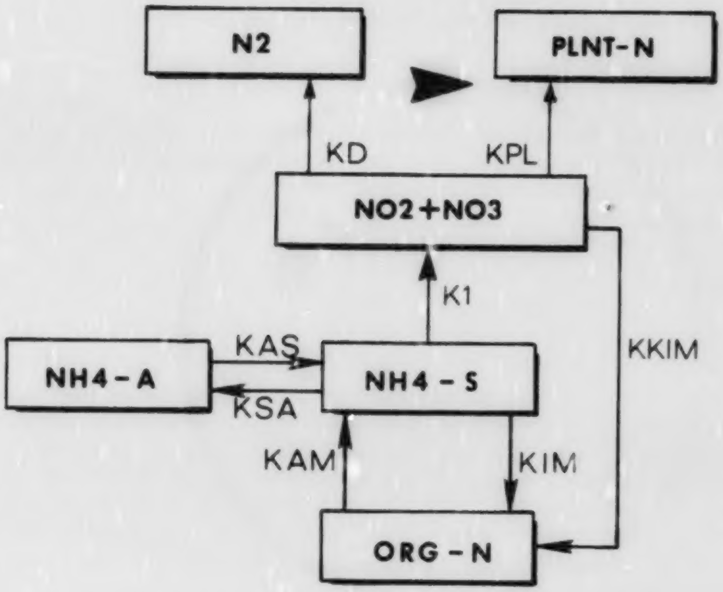
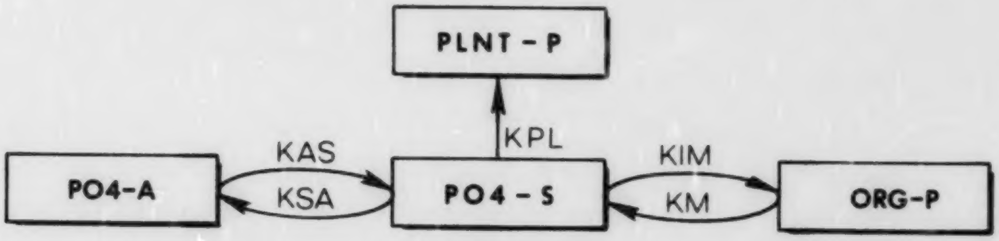


Figure 4.4b Non single-valued adsorption/desorption algorithm

Figure 4.4 Pesticide adsorption/desorption algorithms


N2
PLNT-N
KD
KPL
NO2+NO3
K1
KKIM
NH4-A
KAS
KSA
NH4-S
KAM
KIM
ORG-N

A. Nitrogen transformations in ARM model


PLNT-P
KPL
PO4-A
KAS
KSA
PO4-S
KIM
KM
ORG-P

B. Phosphorus transformations in ARM model

Figure 4.5 Nutrient transformations in the ARM model

uptake by crops.

(e) Modifying algorithms so that transformations are performed in terms of nutrient concentrations in the surface, upper, and lower zones as opposed to nutrient mass in each zone (i.e. kg/ha) as in the previous version.

The above changes are discussed in Sections 6 and 8.

OTHER PROGRAMMING CHANGES

The user will notice two additional changes to the ARM Model source code and input presented in this report. During this study, the ARM Model code was modified in order to operate on a Hewlett-Packard 3000 Series II computer. This required certain internal program modifications due to differences between the HP 3000 and the IBM 360/67 on which the ARM Model was developed. These changes are not apparent to the user. Although the HP3000 does not allow the FORTRAN namelist option, the ARM Model source code in Appendix H retains the namelist option in order to be compatible with input sequences prepared for the previous version of the model.

The ARM Model presently includes an option to output simulated runoff and sediment values to an external storage device (tape, disc, etc) as unformatted FORTRAN records. This option and associated plotting routines were developed in a research effort to develop a basin wide sediment model including in-stream sediment transport simulation (Johanson and Crawford, 1976). Appendix A describes the required input to access this output option in the ARM Model.

SECTION 5

DATA COLLECTION AND ANALYSIS PROGRAMS

The ARM Model development effort is supported by an extensive data collection and analysis program sponsored by the U.S. Environmental Protection Agency's Environmental Research Laboratory in Athens, Georgia (ERL-Athens). Test sites located in Georgia and Michigan have been instrumented for continuous monitoring and sampling of runoff and sediment. Collected samples are refrigerated on site and later analyzed for pesticide and nutrient content. In addition, meteorologic conditions are continuously monitored and soil core samples are taken and analyzed immediately following application and periodically throughout the growing season. Table 5.1 presents pertinent characteristics of the test watersheds. The individual programs in Georgia and Michigan are described in the ARM Model report (Donigian and Crawford, 1976).

During the current study testing efforts were concentrated on the P2 watershed (Figure 5.1) in Georgia and the P6 watershed (Figure 5.2) in Michigan. Both P2 and P6 are natural nonterraced watersheds. Data was available for the 1973 through 1975 growing seasons. Table 5.2 indicates the crops, applied chemicals, target application rates, and dates of application for all test watersheds listed in Table 5.1. P2 and P6 were monitored and analyzed for various pesticides and nutrient forms. This report presents simulation results for both watersheds.

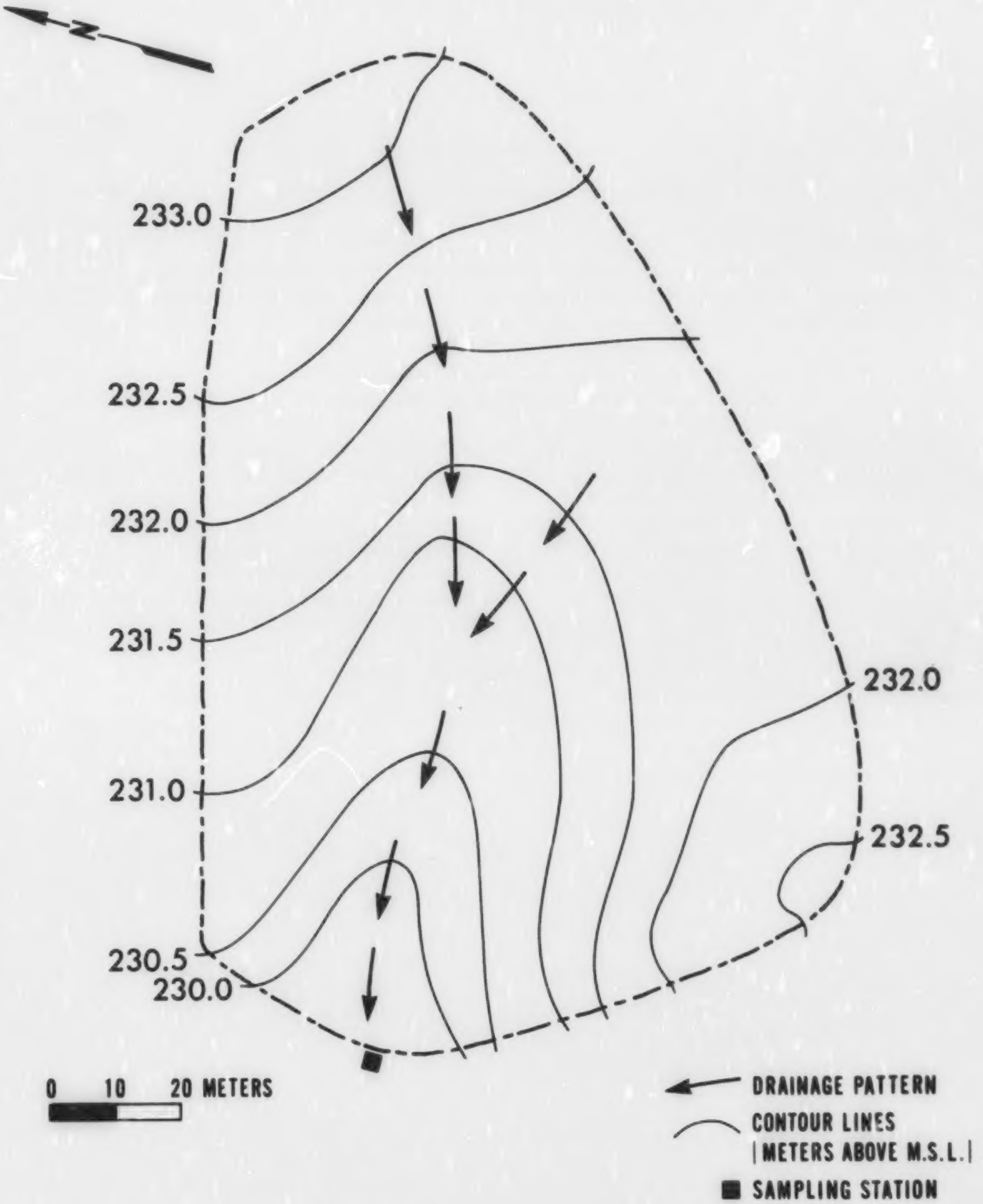

N
233.0
232.5
232.0
231.5
231.0
230.5
230.0
232.0
232.5
0 10 20 METERS
DRAINAGE PATTERN
CONTOUR LINES |METERS ABOVE M.S.L.|
■ SAMPLING STATION

Figure 5.1 P2 Watershed, Watkinsville, Georgia (1.3 ha)

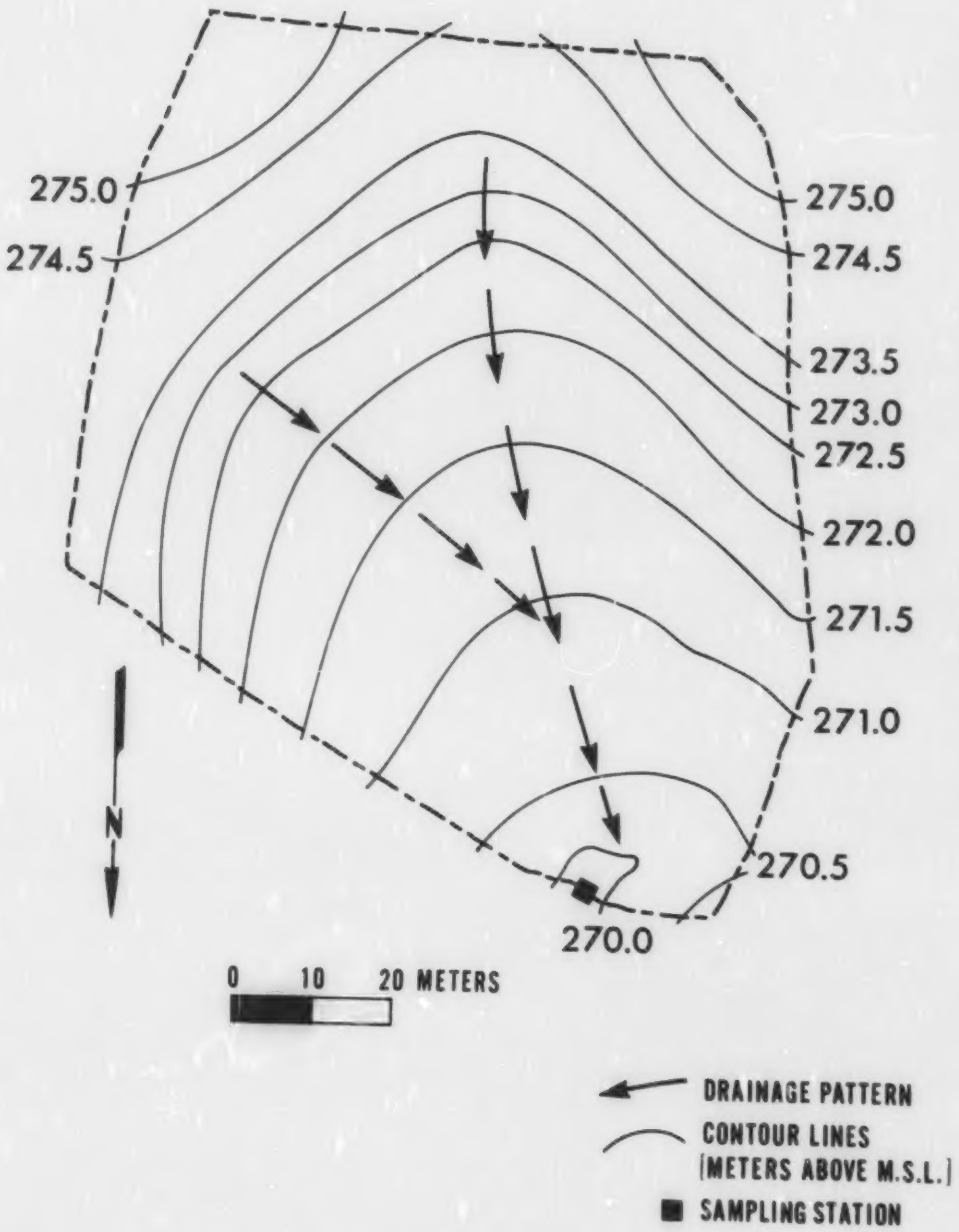

275.0
274.5
275.0
274.5
273.5
273.0
272.5
272.0
271.5
271.0
270.5
270.0
N
0
10
20 METERS
DRAINAGE PATTERN
CONTOUR LINES
(METERS ABOVE M.S.L.)
SAMPLING STATION

Figure 5.2 P6 Watershed, East Lansing, Michigan (0.8 ha)

TABLE 5.1 WATERSHEDS FOR ARM MODEL TESTING

Watershed Designation	Location	Owner/ Operator	Area (ha)	Mean Elevation (m above msl)	Soils	Conservation
P1	Watkinsville, Georgia	USDA/EPA	2.70	238	Cecil sandy loam	Non terraced grass waterway installed 11/74
P2	Watkinsville, Georgia	USDA/EPA	1.30	231	Cecil sandy loam	non terraced
P3	Watkinsville, Georgia	USDA/EPA	1.26	239	Cecil sandy loam	terraced with grass waterway
P4	Watkinsville, Georgia	USDA/EPA	1.38	239	Cecil sandy loam	terraced with grass waterway
P6	East Lansing, Michigan	Michigan State Univ.	0.80	272	Spinks loamy sand, also Traverse/Hillsdale sandy loam	non terraced
P7	East Lansing, Michigan	Michigan State Univ.	0.55	271	Spinks loamy Sand, also Tuscola Sandy loam	non terraced

TABLE 5.2 CROPPING AND CHEMICAL APPLICATIONS FOR THE TEST WATERSHEDS (1973-75)

WATERSHED	1973				1974				1975			
	Crop	Applied Chemical	Application[a] Rate (kg/ha)	Date	Crop	Applied Chemical	Application[a] Rate (kg/ha)	Date	Crop	Applied Chemical	Application[a] Rate (kg/ha)	Date
P1	soybean	nitrogen	21	5-22-73	soybean	nitrogen	17	5-22-74	sorgham	paraquat[b]	1.12[e]	6-2-75[e]
		phosphorus	19	5-22-73		phosphorus	15	5-22-74		propazine[b]	2.8	6-2-75[c]
		nitrogen	25	6-4-73		paraquat[b]	1.12[e]	5-30-74[c]		nitrogen	90	7-7-75
		phosphorus	22	6-4-73		diphenamid[b]	3.36	5-30-74[c]		2,4 D[b]	0.68	7-7-75
		paraquat[b]	1.12[e]	1-13-73[c]		trifluralin[b]	1.12	5-30-74[c]				
		diphenamid[b]	3.36	6-13-73[c]	barley (winter cover)	nitrogen	73	2-1-75				
		trifluralin[b]	1.12	6-13-73[c]		phosphorus	22	2-1-75				
P2[d]	corn	nitrogen	38	5-11-73[c]	corn	nitrogen	38	4-29-74[c]	corn	nitrogen	22	4-24-75
		phosphorus	17	5-11-73[c]		phosphorus	33	4-29-74[c]		phosphorus	21	4-24-75
		paraquat[b]	1.12[e]	5-11-73[c]		paraquat[b]	1.12[e]	4-29-74[c]		paraquat[b]	1.12	5-21-75
		atrazine[b]	3.36	5-11-73[c]		atrazine[b]	3.36	4-29-74[c]		atrazine[b]	1.68	5-21-75
		nitrogen	112	6-23-73		nitrogen	101	6-11-74		cyanazine[b]	1.68	5-21-75
										2,4-D[b]	2.24	5-21-75[c]
										chloride	112	5-21-75[c]
										nitrogen	112	6-25-75
P3	soybean	nitrogen	21	5-22-73	soybean	nitrogen	17	5-22-74	soybean	nitrogen	0	5-8-75
		phosphorus	19	5-22-73		phosphorus	15	5-22-74		phosphorus	15	5-8-75
		nitrogen	25	6-4-73		paraquat[b]	1.12[e]	5-30-74[c]		paraquat[b]	1.12[e]	5-28-75
		phosphorus	22	6-4-73		diphenamid[b]	3.36	5-30-74[c]		diphenamid[b]	3.36	5-29-75[e]
		paraquat[b]	1.12[e]	6-15-73[c]		trifluralin[b]	1.12	5-30-74[c]		trifluralin[b]	1.12	5-28-75[c]
		diphenamid[b]	3.36	6-15-73[c]								
		trifluralin[b]	1.12	6-15-73[c]								
P4[d]	corn	nitrogen	38.5	5-11-73[c]	corn	nitrogen	38	4-29-74[c]	corn	nitrogen	22	4-24-75
		phosphorus	16.7	5-11-73		phosphorus	33	4-29-74[c]		phosphorus	21	4-24-75
		paraquat[b]	1.12[e]	5-11-73		paraquat	1.12	4-29-74[c]		paraquat[b]	1.12	5-14-75[c]
		atrazine[b]	3.36	5-11-73		atrazine	3.36	4-29-74[c]		atrazine[b]	1.68	5-14-75[c]
		nitrogen	112	6-23-73		nitrogen	112	6-11-74		cyanazine[b]	1.68	5-14-75[c]
	rye (winter cover)			10-5-73	rye (winter cover)			10-15-74		2,4-D[b]	2.24	5-14-75[c]
										chloride	112	5-14-75[c]
										nitrogen	112	6-25-75

(continued)

TABLE 5.2 (continued)

WATERSHED	1973 Crop	1973 Applied Chemical	1973 Application[a] Rate kg/ha	1973 Date	1974 Crop	1974 Applied Chemical	1974 Application[a] Rate kg/ha	1974 Date	1975 Crop	1975 Applied Chemical	1975 Application[a] Rate kg/ha	1975 Date
P6[d]	soybean	trifluralin[b]	1.12	6-8-73[c]	corn	nitrogen	56	5-20-74[c]	corn	nitrogen	56	5-16-75[c]
		nitrogen	26.9	6-8-73[c]		phosphorus	112	5-20-74[c]		phosphorus	112	5-16-75[c]
		phosphorus	26.9	6-8-73[c]		chloride	102	5-20-74[c]		chloride	112	5-16-75[c]
		paraquat[b]	1.00	6-9-73		paraquat[b]	1.12[f]	5-22-74		paraquat[b]	1.12[f]	5-17-75
		diphenamid[b]	3.00	6-9-73		atrazine[b]	4.48	5-22-74		atrazine[b]	2.24	5-17-75
		paraquat	0.92	11-5-73		nitrogen	112	7-8-74		nitrogen	112	6-25-75
		diphenamid	2.77	11-5-73		nitrogen	112	11-7-74				
						chloride	112	11-7-74				
						paraquat[b]	1.12	11-8-74				
						atrazine[b]	2.24	11-8-74				
P7[d]	soybean	trifluralin[b]	1.12	6-8-73[c]	soybean	nitrogen	56	5-20-74[c]	soybean	nitrogen	56	5-16-75[c]
		nitrogen	26.9	6-8-73[c]		phosphorus	112	5-20-74		phosphorus	112	5-16-75[c]
		phosphorus	26.9	6-8-73[c]		paraquat[b]	1.12[f]	5-22-74[c]		chloride	112	5-16-75[c]
		paraquat[b]	1.12	6-9-73		diphenamid[b]	3.36	5-22-74[c]		paraquat[b]	1.12[f]	5-17-75
		diphenamid[b]	3.36	6-9-73		nitrogen	112	11-7-74		diphenamid[b]	3.36	5-17-75
		paraquat[b]	1.12	11-5-73		chloride	112	11-7-74				
		diphenamid[b]	3.36	11-5-73		paraquat[b]	1.12	11-8-74				
						diphenamid[b]	3.36	11-8-74				

Notes:
- a target application rates for nitrogen, phosporus, and the following herbicides:
- b pesticide analyses performed
- d both pesticide and nutrients analyzed for these watersheds, except for 1973 on P6 and P7
- c planting day
- e computation based on cation
- f computation based on dichloride salt

Common Name	Chemical name
2,4 D	(2,4-dichlorophenoxy) acetic acid
atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino-s-triazine
cyanazine	2-chloro-4-(1-cyano-1-methylethylamino)-6-ethylamino-s-triazine
diphenamid	N,N-dimethyl-2,2-diphenylacetamide
paraquat	1,1'-dimethyl-4,4'-bipyridinium ion
propazine	2-chloro-4,6-bis(isopropylamino)-s-triazine
trifluralin	α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine

SECTION 6

SOIL ENVIRONMENT SIMULATION

The soil environment plays a key role in the modeling of pesticide and nutrient behavior as these constituents await transport from the land to the stream. Soil moisture and soil temperature are two major characteristics of the soil environment that affect pesticide and nutrient behavior by their impact on chemical and biological transformations. In order to evaluate the significance of these impacts, methods of simulating soil moisture and temperature were developed and incorporated into the ARM Model. Simulated soil moisture and temperature were then used to evaluate alternative pesticide degradation models (Section 7). Also, soil temperature is used to adjust nutrient transformation rates in each of the vertical soil zones.

This section discusses the methods developed for simulating soil moisture and temperature in each of the vertical soil zones represented in the ARM Model. Test results are presented and recommendations for future research topics are provided. In addition, the problem of leaching or vertical movement of pollutants is addressed as a function of soil moisture conditions and soil characteristics. The extent of leaching of applied chemicals determines the amount of pollutants available for transport from each vertical soil zone during a storm event. A procedure to simulate the leaching characteristics of a watershed within the framework of the present hydrologic model is described.

SOIL MOISTURE SIMULATION

Since the LANDS routine of the ARM Model continuously calculates indices of the moisture status of the soil profile, the goal of the soil moisture simulation was to quantify the relationship between these indices and percent soil moisture values for the surface, upper, and lower zones. The LANDS routine (Figure 6.1) continuously determines the amount or depth of water in storage in each zone. Nominal storage values, determined through calibration, are specified for the upper (UZSN) and lower (LZSN) zones. The soil moisture conditions of these zones are represented as the ratios of the existing storages (UZS and LZS) to their nominal storage capacity. As these capacities are nominal and not absolute, the ratios UZS/UZSN and LZS/LZSN can have values greater than one. Consequently, these ratios are related to percent soil moisture, but are not actual soil moisture values. For the surface zone no nominal storage capacity is specified. The surface zone is considered to be the zone of wetting by overland flow and contains moisture only when overland flow is occurring.

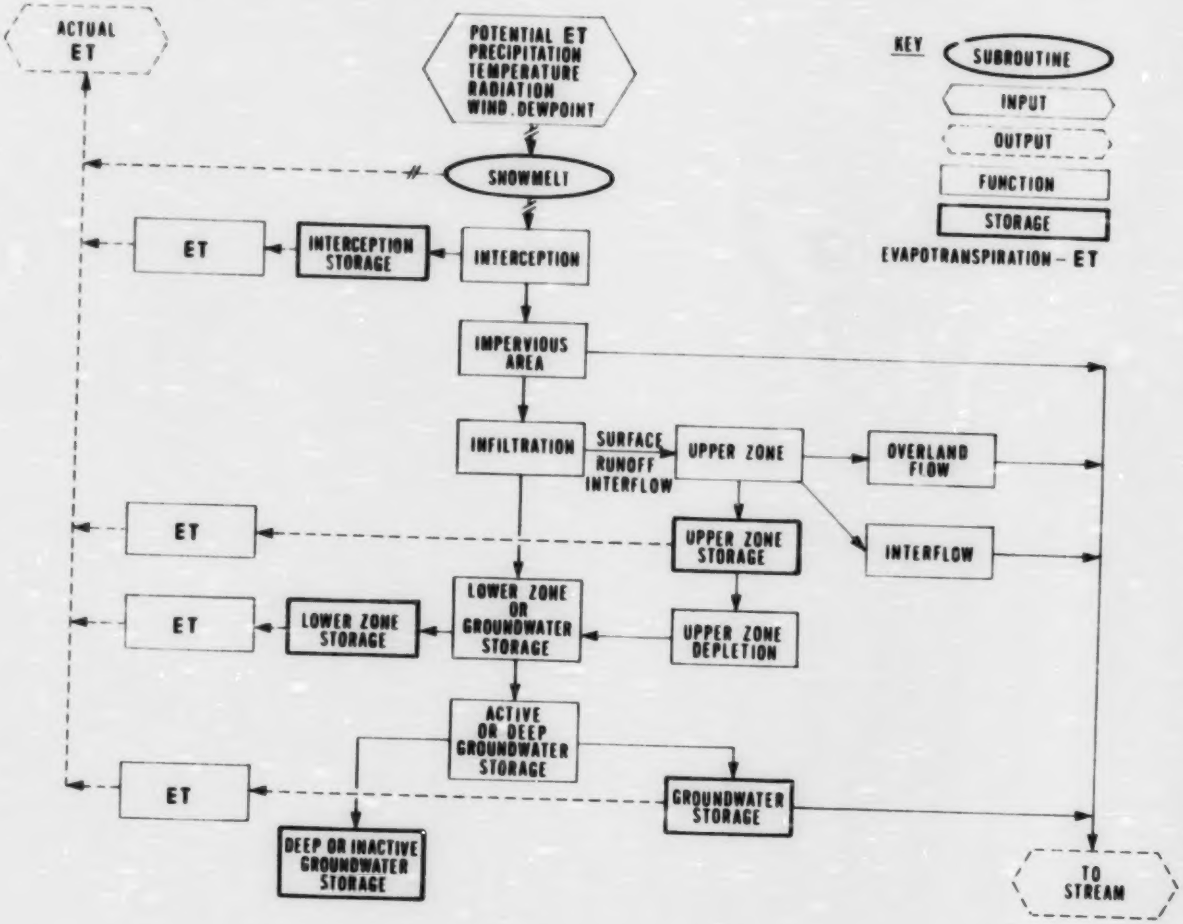

ACTUAL ET
POTENTIAL ET
PRECIPITATION
TEMPERATURE
RADIATION
WIND, DEWPOINT
KEY
SUBROUTINE
INPUT
OUTPUT
FUNCTION
STORAGE
EVAPOTRANSPIRATION - ET
SNOWMELT
ET
INTERCEPTION STORAGE
INTERCEPTION
IMPERVIOUS AREA
INFILTRATION
SURFACE
RUNOFF
INTERFLOW
UPPER ZONE
OVERLAND FLOW
ET
UPPER ZONE STORAGE
INTERFLOW
ET
LOWER ZONE STORAGE
LOWER ZONE OR GROUNDWATER STORAGE
UPPER ZONE DEPLETION
ACTIVE OR DEEP GROUNDWATER STORAGE
ET
GROUNDWATER STORAGE
DEEP OR INACTIVE GROUNDWATER STORAGE
TO STREAM

Figure 6.1 LANDS simulation

To obtain soil moisture values, relationships were developed between the upper and lower zone ratios and recorded soil moisture data collected on the Georgia watersheds. Daily maximum and minimum UZS/UZSN values were compared to daily percent soil moisture values at five cm depth for the summer of 1973 (Figure 6.2). Obviously, the single daily recorded soil moisture values in Figure 6.2 demonstrate much less variability than the calculated range of UZS/UZSN values. This is to be expected since the calculated ratios include both storm and nonstorm periods, while the recorded measurements are generally made during non-storm periods after percolation and re-distribution of the soil water has occurred. In general, the upper zone ratio and the 5 cm soil moisture behave in a similar manner. From this comparison the following linear relationship for the upper zone soil moisture was developed:

$$x = \frac{y + 0.48}{24} \tag{6.1}$$

where x = soil moisture fraction (by weight) at 5 cm depth.
y = UZS/UZSN

Figure 6.3 show how the simulated maximum and minimum soil moisture values from Equation 6.1 compare with the 5 cm recorded data. As noted above, the maximum and minimum simulated values are more variable but they generally bracket the recorded values during storm periods. During dry periods the simulated values are generally lower than recorded. However, the overall accuracy is sufficient for evaluating the pesticide degradation algorithms.

For the lower zone we compared the LZS/LZSN ratio with recorded soil moisture at 23 and 38 cm (Figure 6.4). The lower zone ratio is much less variable than the upper zone ratio and behaves much like the 38 cm depth recorded soil moisture. This indicated that the 38 cm depth soil moisture could be simulated using the ratio LZS/LZSN. The relationship developed is given by Equation 6.2:

$$x = 0.1404\ y^{2.66} \tag{6.2}$$

where x = soil moisture fraction (by weight) at 38 cm depth
y = LZS/LZSN

Figure 6.5 shows that the simulated and recorded soil moisture values at 38 cm are in good agreement for the 1973 growing season on the P3 watershed. Although Equation 6.2 may not be valid for other seasons, the simulation is sufficiently accurate for evaluating pesticide degradation models with the summer data on the Georgia watersheds.

The surface zone is the only remaining portion of the soil profile in which soil moisture needs to be calculated. Since the model assigns moisture to the surface zone only when overland flow occurs, the surface soil moisture is usually zero except during storm events when the soil moisture is determined by the following equation:

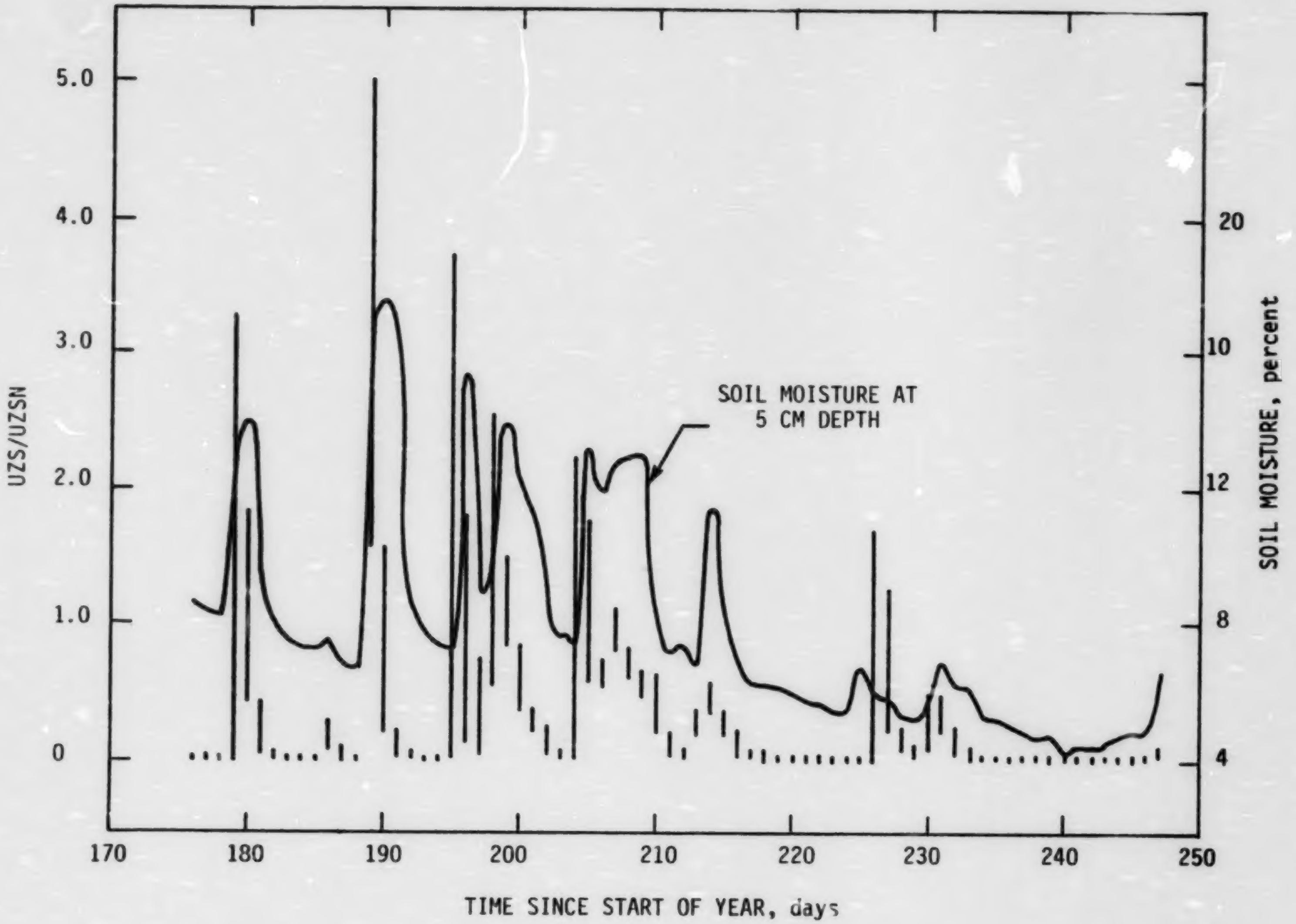


Figure 6.2 Comparison of soil moisture and UZS/UZSN at Watkinsville, 1973

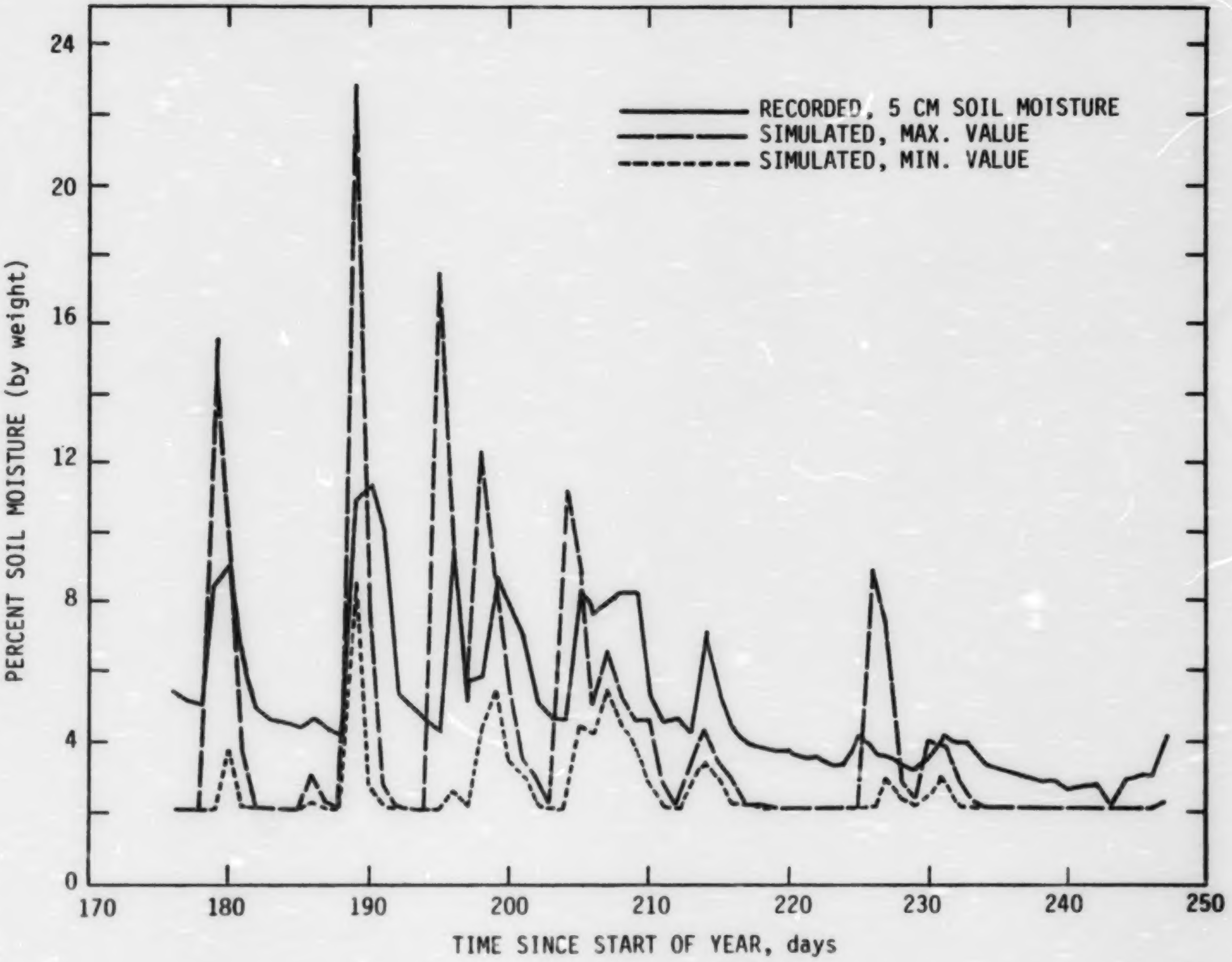


Figure 6.3 Soil moisture at 5cm depth at Watkinsville, 1973

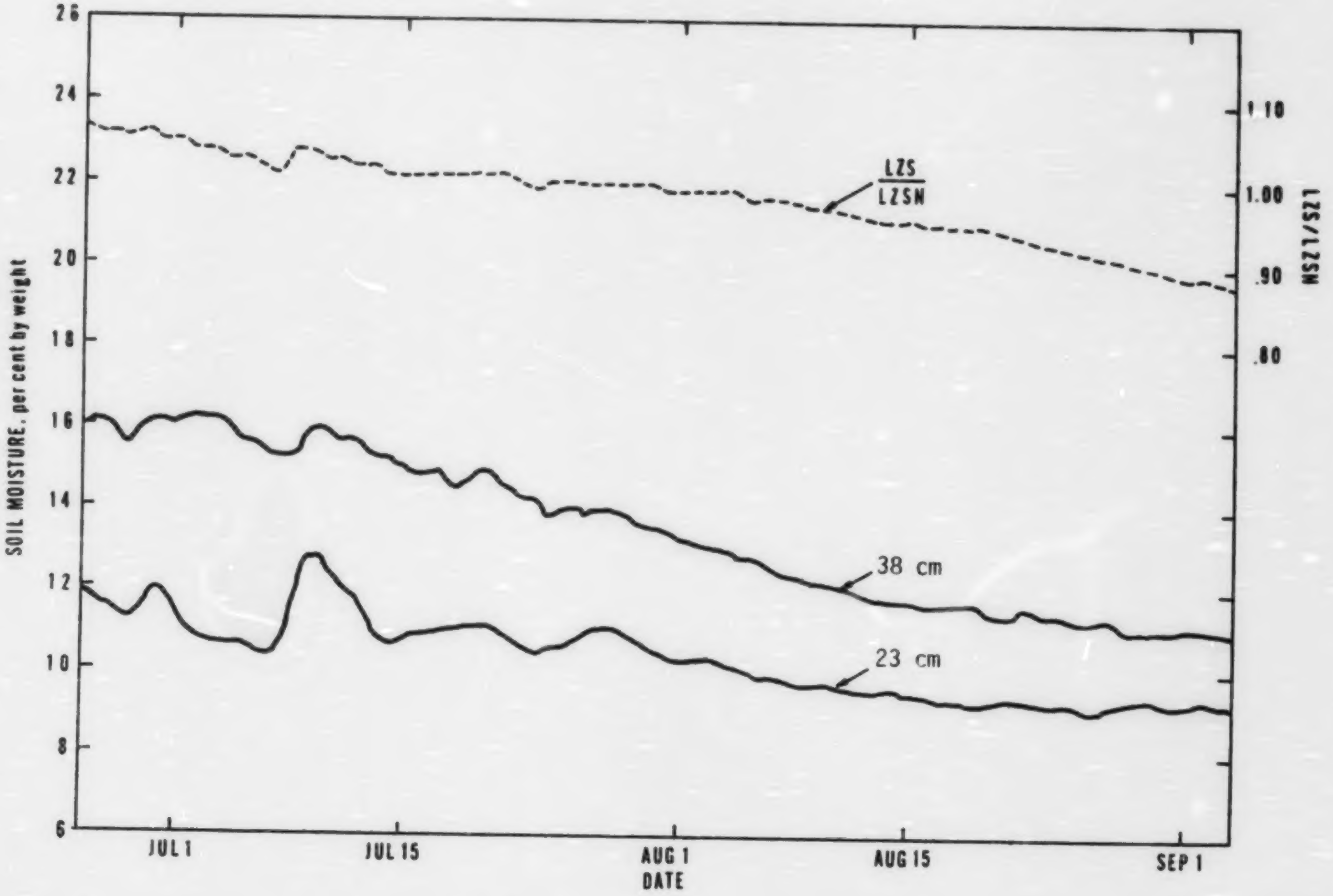


Figure 6.4 Comparison of soil moisture and LZS/LZSN at Watkinsville, 1973

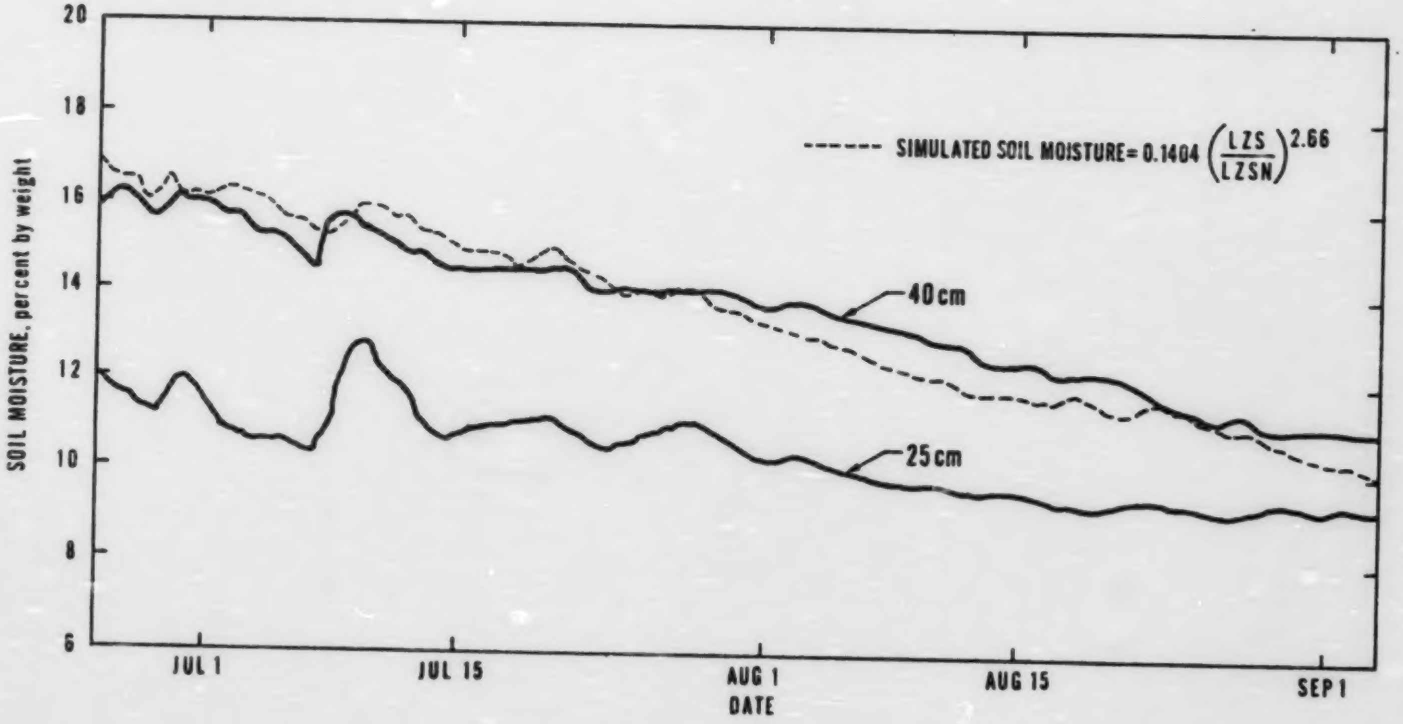


Figure 6.5 Soil moisture at 40 cm depth at Watkinsville, 1973

$$X(t) = VTOW * RESB(t)/M \qquad (6.3)$$

where X(t) = soil moisture fraction (by weight) at the surface zone during time interval t.
VTOW = 45302.4*AREA, a constant to convert depth of water to weight of water.
RESB(t) = depth of water in each block of the surface zone during time interval t.
M = weight of soil for each block of the surface zone.

Obviously Equation 6.3 is a gross approximation of the soil moisture behavior in the surface soil layer of a watershed. However, this representation was satisfactory for our purposes since a detailed accounting of the surface zone characteristics was not possible in this project. Future modeling work should investigate more detailed methods of representing the surface zone.

With the above equations, soil moisture can be approximated at 3 points: the surface zone, at 5 cm depth, and at 38 cm depth. To evaluate the variability of soil moisture values with depth and time, we analyzed recorded soil moisture data for the period of April through November 1974 for the Georgia watersheds. As would be expected, soil moisture is most variable at the surface, and the variation decreases with depth. Below 50 cm the moisture values are relatively uniform. The maximum observed values irrespective of depth were in the range of 20 to 30 percent. The data indicated that the soil moisture profile can be approximated given the following assumptions:

(1) Linear interpolation can be used to calculate soil moisture values between 5 and 38 cm depth.
(2) Simulated soil moisture values at 38 cm depth will be representative of moisture values at greater depths.

Thus, the three soil moisture equations and the above assumptions allow the ARM Model to calculate soil moisture at all necessary depths. Currently it is assumed in the model that the five and 38 cm depths are representative of the upper and lower zones, respectively. The accuracy of the simulated results compared to the recorded data is sufficient for evaluation of the alternative pesticide degradation algorithms. As will be discussed in Section 7, the degradation algorithm that corrects for soil moisture conditions was not found to be the best approach to pesticide degradation. Therefore, simulated values of percent soil moisture are not currently used in the ARM Model. However, the soil moisture equations remain in the LANDS subroutine (Appendix D) and with only minor programming changes could be available for other uses in the model.

LEACHING OF SOLUTES

The vertical movement or leaching of soluble pollutants (solution pesticides and nutrients) affects the amount of soluble pollutant available for transport to the stream from each vertical soil zone. The leaching of soluble pollutants is important since they can reach the stream by (1) overland flow from the surface zone, (2) interflow from the upper zone, and (3) groundwater flow through the pathway of the lower and groundwater zones. On the other hand, sediment-associated pollutants are transported solely from the land surface where erosion takes place.

Initial nutrient simulation results showed that solution nutrients, as representd in the model, were percolating much more rapidly than indicated by the recorded data. In fact the nonreactive solutes not adsorbed to soil particles, such as NO_3 and Cl, were simulated as completely washed to the lower zone from the surface and upper zones with only minimal rainfall amounts. Soluble PO_4 and NH_4 behaved similarly but the impact was not as dramatic because the simulated adsorption process allowed the adsorbed PO_4 and NH_4 to remain in the surface and upper zones. Further investigation showed that rapid leaching also occurred for the soluble pesticide forms but eluded detection because of the simulated adsorption/desorption process and the small pesticide fraction in soluble form. The end result of the rapid leaching was the depletion of soluble pollutants in the surface and upper zones and the absence of these forms in surface runoff and interflow.

Analysis of the simulation results and review of the model algorithms showed that the following factors contributed to the rapid leaching problem:

(1) Assumptions on the areal variation of infiltration characteristics in LANDS.
(2) Extremely small values of UZSN calibrated on the Georgia watersheds.
(3) Model assumptions relating chemical movement to simulated water movement.

The LANDS routine algorithms were originally developed for natural, rural watersheds where the assumption of spatially varying infiltration rates is more applicable than for managed agricultural lands. Agricultural practices like plowing, harrowing, cultivating, and terracing tend to establish relatively uniform properties on the land surface to the depth of tillage operations. The infiltration function in LANDS (Figure 6.1) distributes, in each time step, the available moisture on the land surface to the upper, lower, and groundwater zones as a function of the lower zone soil moisture and the input infiltration rate. The portion assigned to the upper zone is then divided among the overland flow, interflow, and upper zone storage components. The remaining portion of the available moisture is assigned to and reaches the lower zone or groundwater zone. In the initial work on the LANDS algorithms, the upper zone was considered a noncontinuous layer of near surface and detention storage and the lower zone was assigned the infiltrated moisture directly from the surface. With our present layered representation of the soil profile (Figure 4.2), this moisture assigned to the lower zone must first travel through the surface and upper soil zones. On its way to the lower zone, this moisture component transports soluble pollutants from the other zones and thus is the basic cause of the rapid leaching problem.

In developing a solution to the leaching problem we decided to retain the present LANDS algorithms as a constraint on any solution approach adopted. The success of LANDS and related versions of the Stanford Watershed Model, and the emphasis on pesticide and nutrient simulation in this work precluded a major revision of the LANDS algorithms. This decision should be re-evaluated in future work if a more detailed simulation of the soil profile is required. However, as will be discussed below and in Sections 7 and 8, correcting the second and third factors contributing to the rapid leaching has provided a satisfactory solution to the problem for our purposes.

The second factor contributing to the rapid leaching problem was the extremely small UZSN value determined by calibration of the Georgia watersheds in previous studies (Crawford and Donigian, 1973; Donigian and Crawford, 1976). A UZSN value of 0.13 cm (0.05 in) was needed to simulate the surface runoff response of the watersheds to the high intensity, short duration summer thunderstorms. Such a small UZSN effectively represents an upper zone 2 to 3 cm deep, whereas the actual depth of the upper zone was specified as 15 cm. This conflict points out the need for the calibrated parameters to be compatible with the user's perception of the soil profile. With minimal storage capacity in the upper zone, as indicated by the small UZSN, the moisture assigned to the lower zone in each time interval completely depletes the soluble pollutants residing in the upper zone. To correct this situation, the P2 watershed was recalibrated to obtain a more realistic value of 1.27 cm (0.5 in) for UZSN at the expense of some accuracy in the surface runoff simulation (Section 9). The higher UZSN significantly slowed the leaching rate but did not completely solve the problem. This lead to an evaluation of the leaching computations in the model as discussed below.

With the four soil zones in our assumed soil profile (Figure 4.2), soluble chemicals can be transferred from the surface to the upper zone, from the upper zone to the lower zone, and from the lower zone to the groundwater zone. The way in which chemical movement between zones was calculated, which contributed to the rapid leaching, can be represented as:

$$FP = D/(S + D) \tag{6.4}$$

where FP = fraction of soluble chemical leached from the zone
D = moisture leached from the zone or passing through the zone
S = moisture storage in the zone

Since S + D is the total moisture in the zone, Equation 6.4 simply states that the moisture fraction leaving a zone transports the corresponding fraction of the amount of soluble chemical available in the zone. FP, which is always less than or equal to 1.0, is calculated in each time interval for each soil zone and is applied to the mass of each soluble chemical (e.g. NO_3, solution PO_4, solution NH_4, Cl) stored in the zone. The values of S and D are determined in LANDS and transferred to the pesticide and nutrient routines.

For the surface zone, S is greater than zero only during a storm event since no moisture storage parameter is provided. The value of FP is close to 1.0 most of the time; thus, all soluble chemicals applied to the surface zone are leached to the upper zone at the first rainfall event following application. This is a reasonable approximation because of the small depth of the surface zone. For the lower zone, the moisture storage S is large (46 cm for the Georgia watersheds) compared to D, and the resulting FP is small during any time interval. Consequently, the major leaching problem occurred from the upper zone where the original small UZSN produced a corresponding small or zero value for S in the upper zone resulting in an FP value close to 1.0. This caused the rapid leaching of all soluble chemicals from the upper zone to the lower zone for even minor rainfall events. With an upper zone depth of 15 cm, such rapid leaching was contrary to both the physical mechanisms and the recorded data.

Although the recalibrated UZSN slowed the leaching rate, the basic cause of the problem was the assumption inherent in Equation 6.4 that the solute movement always occurs at the same rate as the simulated water movement. Frere (1975) states that a bell-shaped distribution will develop about the solute peak concentration due to nonuniform water movement. This nonuniformity is similar in concept to the spatial variation of infiltration simulated in LANDS. Rao et al. (1976b) have indicated that the peak solute concentration will move with the wetting front when the incoming water and solute enters initially dry soil. For moist soils, the solute peak will lag behind the wetting front because the soil water present in the profile will be displaced ahead of the incoming water. This displacement process is adequately represented in the model by Equation 6.4 at high moisture conditions but not at low moisture levels in the upper zone. Therefore, leaching factors have been incorporated into the upper (UZF) and lower (LZF) zone calculations to adjust the simulated leaching process. For the upper zone, solute leaching is now calculated as follows:

$$USRP = UDS * FP * UZFM \qquad (6.5)$$

where

$$UZFM = UZS/(UZF*UZSN), UZFM \leq 1.0 \qquad (6.6)$$

USRP = upper zone soluble chemicals removed by leaching or percolation, kg/ha
UDS = upper zone soluble chemicals initially present, kg/ha
FP = water percolation factor from Equation 6.4
UZSN = nominal upper zone soil moisture capacity, cm
UZF = upper zone chemical percolation factor

Since the multiplication factor UZFM is always less than or equal to 1.0, solute leaching is lower than that previously calculated. The quantity UZF*UZSN represents a soil moisture condition whereby the initial soil water and associated solute can be completely displaced by incoming water, i.e. plug-flow or piston-type displacement can occur. Thus, when UZS is greater than or equal to UZF*UZSN, UZFM equals 1.0 and the initial solute is displaced by the fraction of the soil water percolated, FP. When UZS is less than UZF*UZSN, UZFM is less than 1.0 and serves to reduce the solute percolated from that calculated by complete displacement. Physically, the case of UZS less than UZF*UZSN can be visualized as a dry soil condition whereby moisture can move through empty flowpaths in the upper zone without transporting solutes stored in the zone. UZFM evaluated as the ratio

UZS/(UZF*UZSN) would then represent the fraction of available flowpaths through the upper zone where no solute transport occurs. Thus, when UZFM equals 1.0 all flowpaths are occupied and complete displacement occurs. Although this description may not be a precise explanation of the physical processes, it does indicate the behavior of the simulated leaching process in the model that has been satisfactory to date. Figure 6.6 indicates how UZFM varies for different values of UZF and the UZS/UZSN ratio.

For consistency, a lower zone leaching factor (LZF) that functions similarly to UZF has been incorporated in the lower zone calculations. Currently UZF and LZF are user-specified calibration parameters with internal default values of 1.0. These parameters affect both pesticide and nutrient leaching. They should be calibrated on soil storage and percolation characteristics of a nonreactive solute, such as chloride, so that the leaching effect will not be masked by transformations. The magnitude and sensitivity of the leaching factors will depend upon soil and solute characteristics and the UZSN and LZSN values. A watershed with sandy, highly permeable soil will have smaller values than a watershed with less permeable soils and hardpans. UZF values of 5.0 and 1.0 were used for P2 and P6 watersheds, respectively. LZF was kept at 1.0 for both watersheds. The lower calibrated UZF value for P6 was understandable since this watershed is sandier and more permeable than P2.

In summary, the method of representing solute leaching described above was added to the ARM Model to reduce rapid solute leaching resulting from the vertical moisture transfer simulated in the LANDS program. It provides a flexible mechanism for the user to approximate the vertical distribution of solutes in the soil profile. Although the solution procedure is not rigorous with regard to the actual leaching process, it is compatible with the LANDS routine and appears to provide sufficient accuracy at the present time. If future work requires greater reliability, research efforts should concentrate on a joint evaluation of the solute leaching and the infiltration/percolation processes.

SOIL TEMPERATURE SIMULATION

Soil temperature simulation is needed to test soil pesticide degradation algorithms and adjust nutrient transformation rates. Nutrient

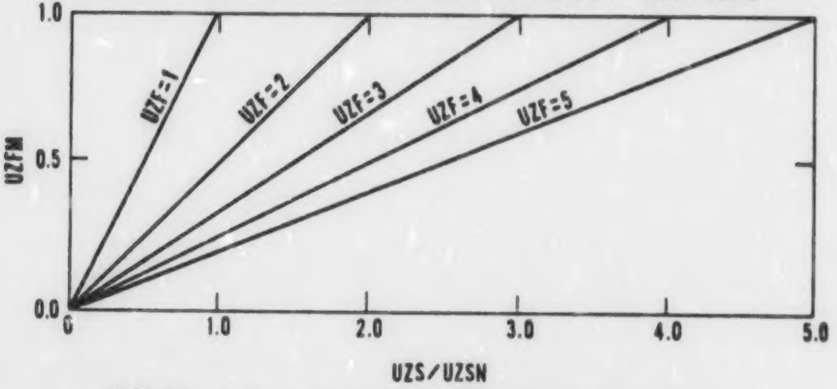


Figure 6.6 Variability of UZFM with UZF

transformation rates in the ARM Model are corrected for soil temperatures by a simplified Arrhenius equation. Both the pesticide and nutrient algorithms need a reasonably accurate input of soil temperatures in the surface, upper, and lower zones in order to model soil processes.

Various approaches to soil temperature simulation were considered in this work. The most physically realistic approach would be a detailed energy balance model based on work similar to that of DeVries (1958) or Wierenga and DeWit (1970). However, development of an energy balance soil temperature model as a function of solar radiation, air temperature, crop cover, and soil properties was considered beyond the scope of this project.

Consequently, other less rigorous approaches were studied. Davidson and Choy (1974) developed a diurnal soil temperature model that uses surface soil temperature to calculate soil temperature at any depth as a pure harmonic function of time around an average value. Air temperature and solar radiation correlations were used to calculate the surface soil temperatures. Simulation results from the Davidson and Choy model were compared to a linear regression approach based on air temperature and solar radiation for eight days of recorded hourly summer data from Watkinsville, Georgia. Since the regression approach was slightly more accurate and easier to implement, it was chosen for soil temperature simulation in the ARM Model.

Soil temperature data at various depths from Watkinsville, Georgia were used to further test and derive regression equations for each of the soil zones. The data were recorded on small plots consisting of Cecil fine sandy loam located next to the P3 and P4 watersheds. Using eight days (July 21-28, 1973) of recorded soil temperature at 1 cm depth, the following regression equation for the surface zone was derived:

$$\mathrm{STEMP} = -29.67 + 1.351(\mathrm{AT}) \tag{6.7}$$

where STEMP = surface zone temperature, °C
AT = air temperature at 120 cm, °C

Originally radiation was also included as an independent variable in the equation, but its effect was so minor that it was eliminated. The upper zone temperature (UTEMP), based on the computed surface zone temperature, is calculated from the following regression developed from soil temperatures at the 5 cm depth:

$$\mathrm{UTEMP} = -3.22 + 0.675(\mathrm{STEMP}) \tag{6.8}$$

After the above equations were developed on eight days of data, they were then used to generate the surface zone and upper zone values for the 1 cm and 5 cm recorded data in Figures 6.7 and 6.8. The data were measured on small plots planted in soybeans on June 5. The accuracy of the simulation, within 10 to 15 percent of observed data, is reasonable since canopy shading effects were ignored. The hourly air temperature values used to produce these results were generated by the ARM Model from input daily maximum and minimum air temperatures. The ARM Model assumes that the daily maximum air

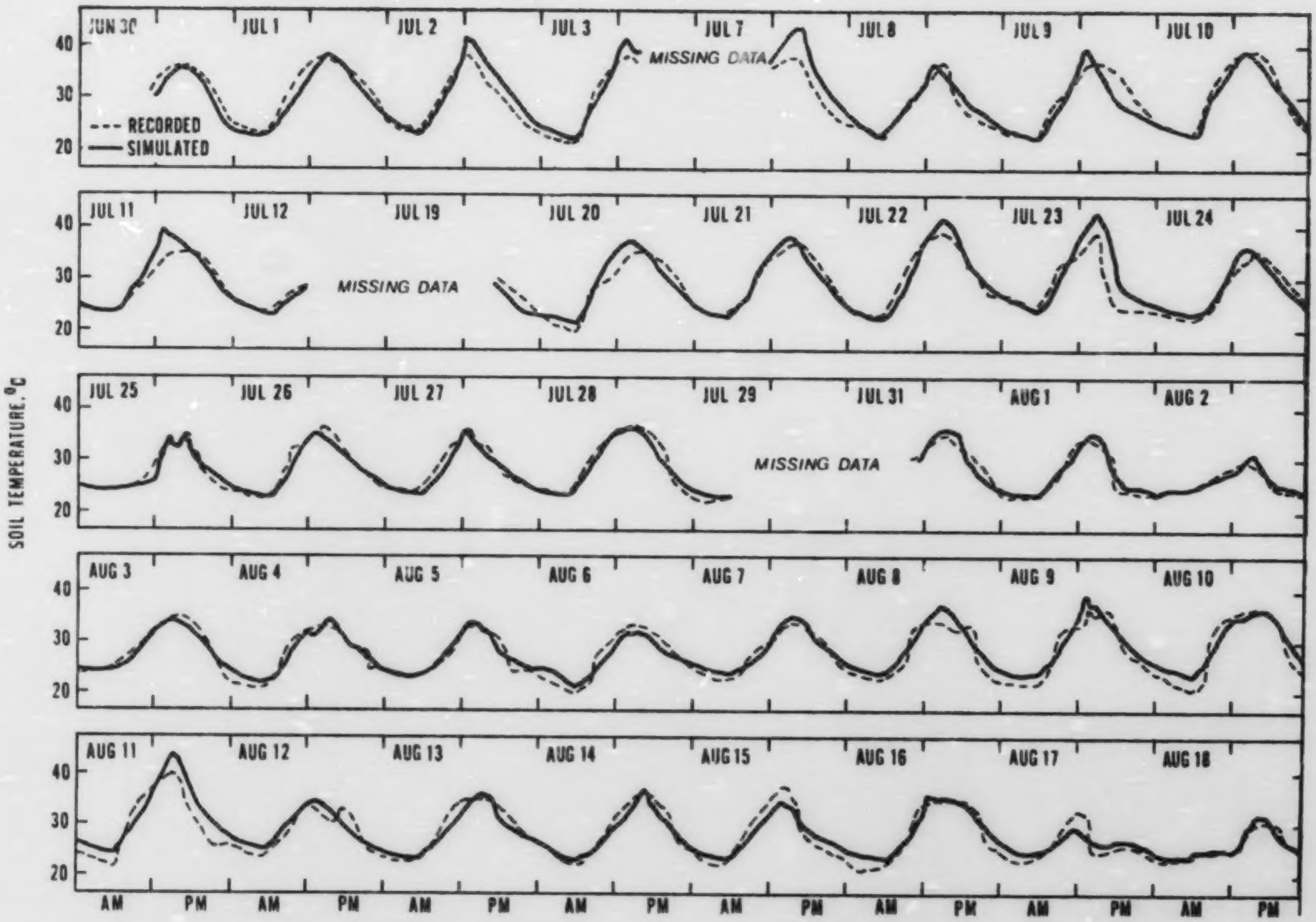


Figure 6.7 Surface zone temperature simulation at Watkinsville, 1973

(continued)

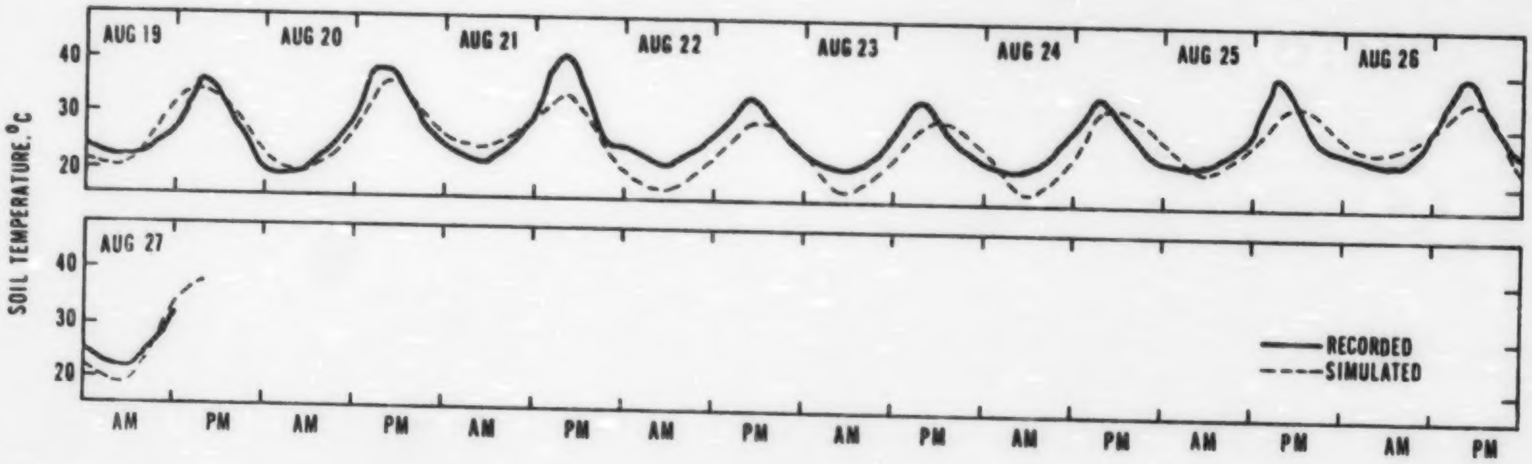


Figure 6.7 (Continued)

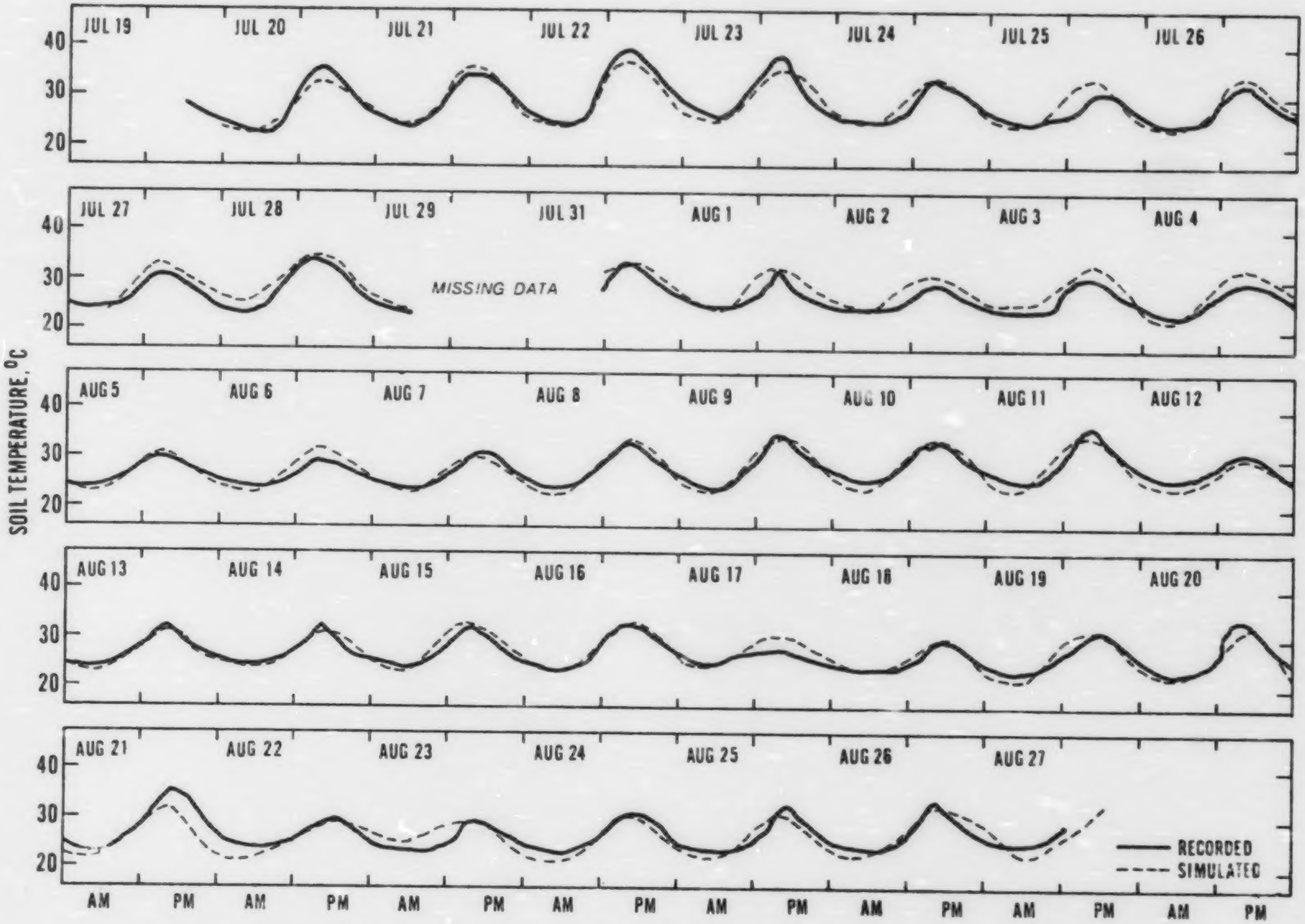


Figure 6.8 Upper zone temperature simulation at Watkinsville, 1973

temperature occurs between 3 and 4 p.m. and that the minimum occurs between 6 and 7 a.m. The other hourly values are derived from a sinusoidal interpolation between the maximum and minimum temperatures.

The above equations for the surface and upper zones were also tested for the summer of 1975. The results are shown in Figures 6.9 and 6.10. During this period the recorded data were taken from small plots planted in corn. The simulated results are somewhat less accurate than the 1973 simulation but are still generally within 15 percent. Deviations of this magnitude (10 to 20 percent) do not appear to be detrimental to the simulation of soil transformations. Rao et al. (1976b) of the University of Florida, using first-order reaction rates in a nitrogen transformation model, have indicated that a twofold increase in the reaction rates should not result in significant differences in the amounts of nitrogen transformed. However, sensitivity analysis using the actual calibrated reaction rates should be performed in order to test this conclusion in the ARM Model.

For the Michigan test watersheds observed soil temperature values at the 5 cm depth were used to develop a regression equation for the upper zone. Maximum and minimum air and soil temperature values for July and August, 1974, provided the basis for the following equation;

$$UTEMP = 7.20 + 0.39(AT) \tag{6.9}$$

The recorded data were taken from Miami fine sandy loam under fescue grass. The simulation results (Figure 6.11) are again generally within 15 percent. However, regression equations based on max-min air temperatures appear to be less accurate than ones based on hourly values as in Georgia. Also, the observed values in Figure 6.11 are for fescue grass whereas the equation was used for corn and soybean watersheds.

A different regression equation for the upper zone was developed for the summer of 1975 and provided significantly better results than Equation 6.9 used for 1974. Thus, different equations were used for the two summer periods simulated. Figure 6.12 shows the simulation results for the 1975 summer using the following equation:

$$UTEMP = -4.29 + 0.63(AT) \tag{6.10}$$

Since no soil temperature data were available for the nonsummer period at Watkinsville, the same regression equations were used for the entire simulation period. In Michigan maximum and minimum winter soil data were available for comparison with the regression equation. The observed winter soil temperatures were considerably more stable than the predicted values. The insolating effect of snow and ice extremely dampened the daily effect of air temperature on soil temperatures. Special consideration for the nonsummer months will be needed for winter simulation runs in areas where snow accumulation is significant.

The soil temperature values calculated for the upper zone were also used for the surface zone for the Michigan P6 watershed since no observed data shallower than 5 cm were available. The lower zone and groundwater zone

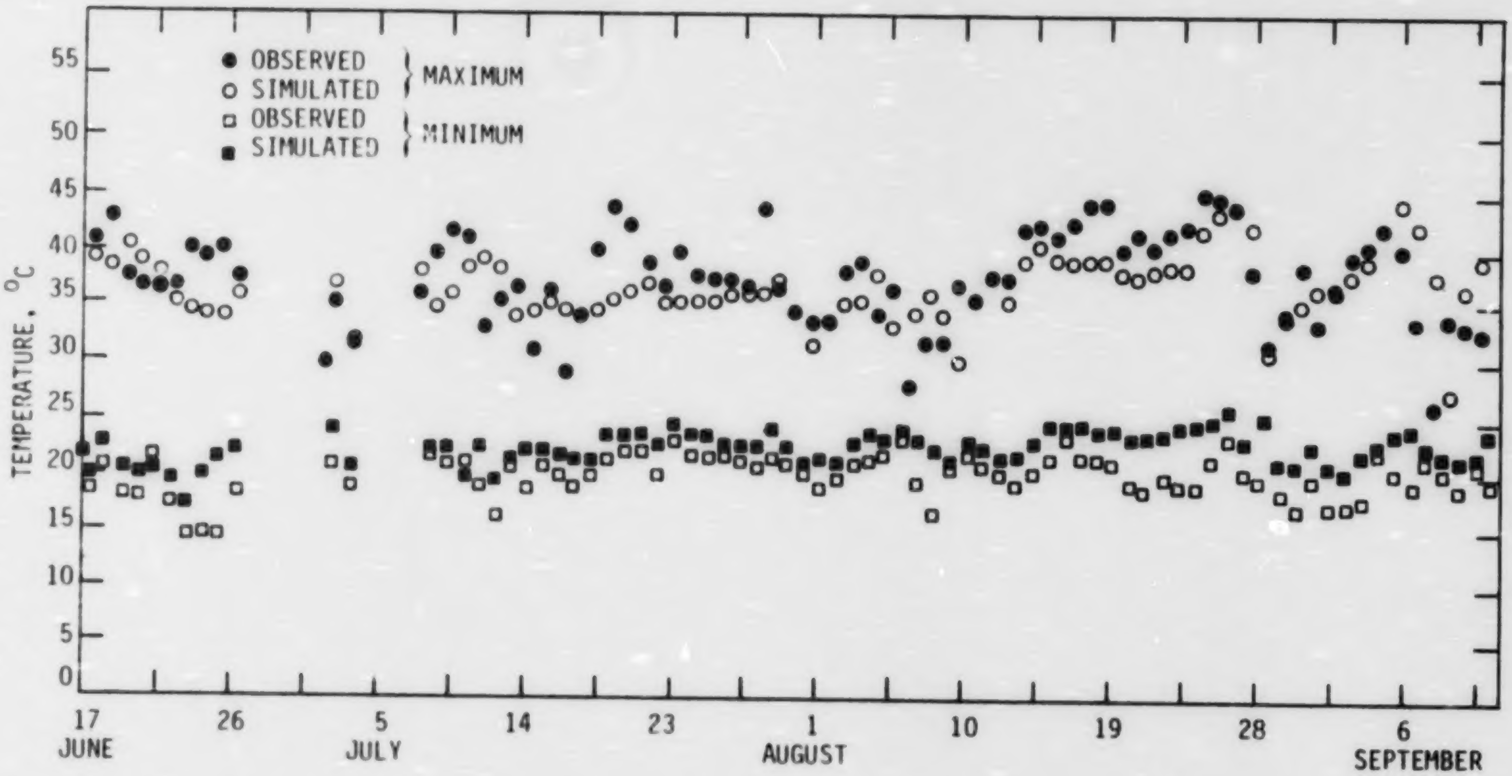


Figure 6.9 Surface zone maximum and minimum daily temperature results at Watkinsville, 1973

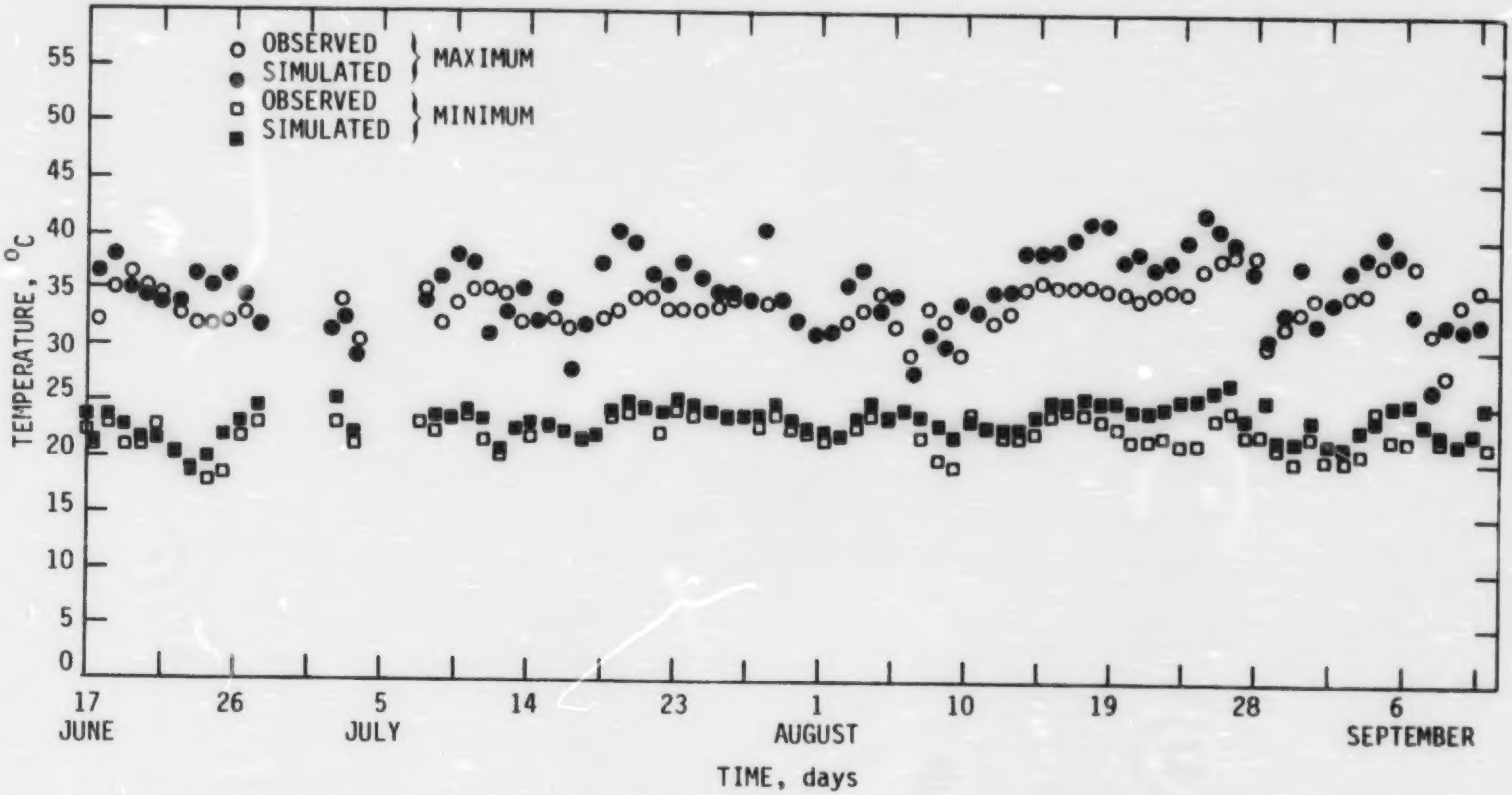


Figure 6.10 Upper zone maximum and minimum daily temperature results at Watkinsville, 1975

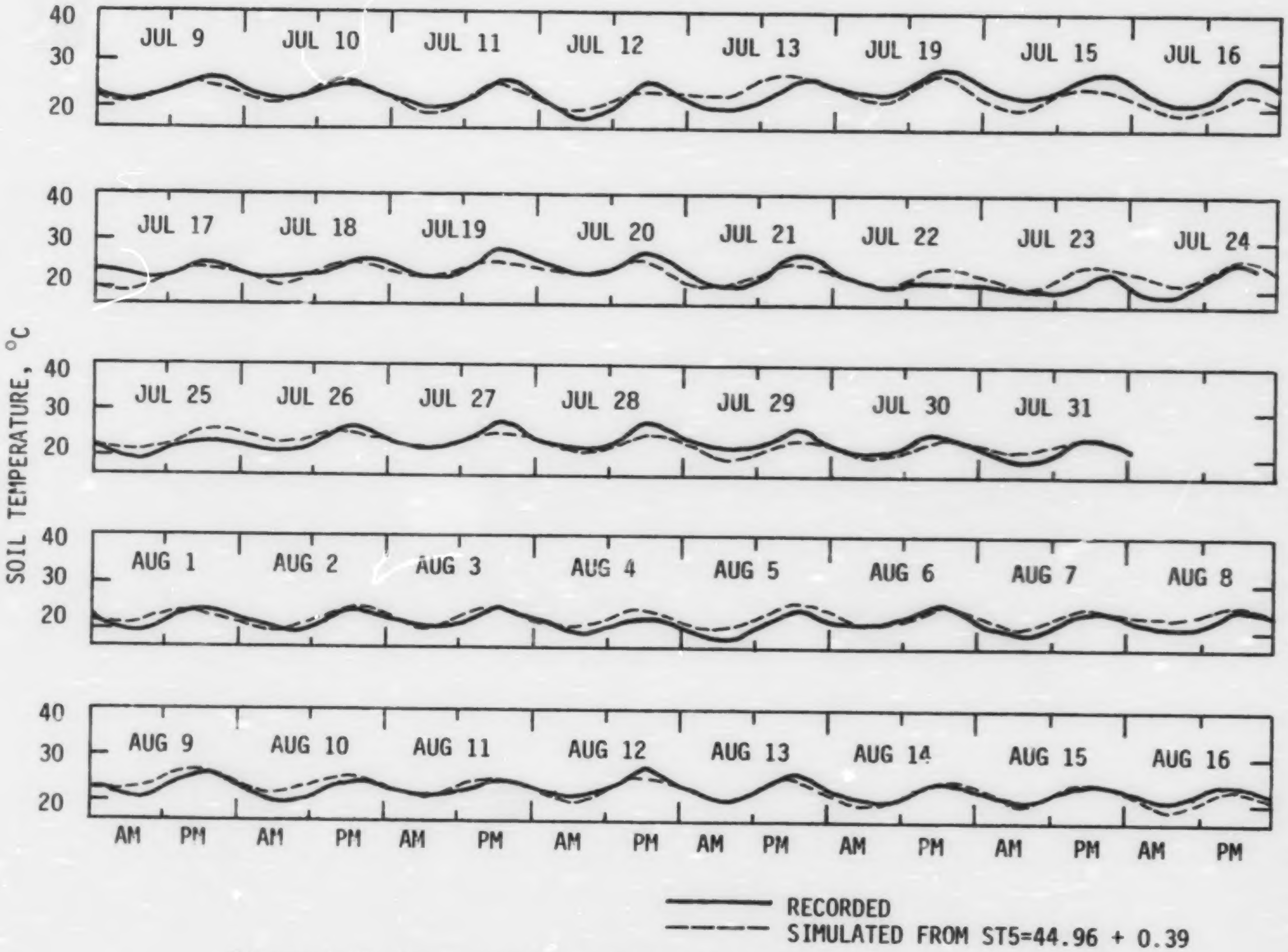


Figure 6.11 Upper zone temperature simulation at East Lansing, 1974

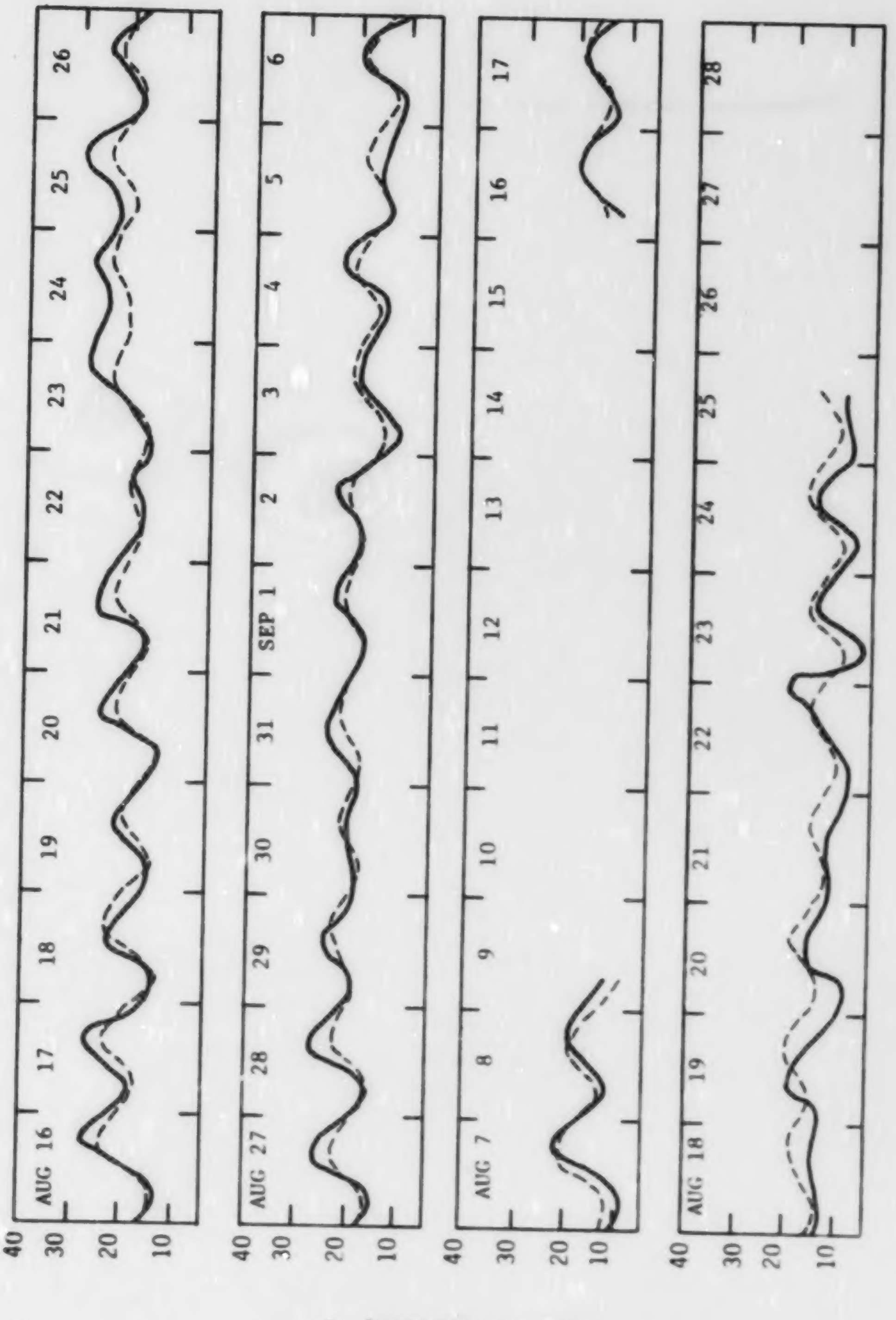


Figure 6.11 (Continued)

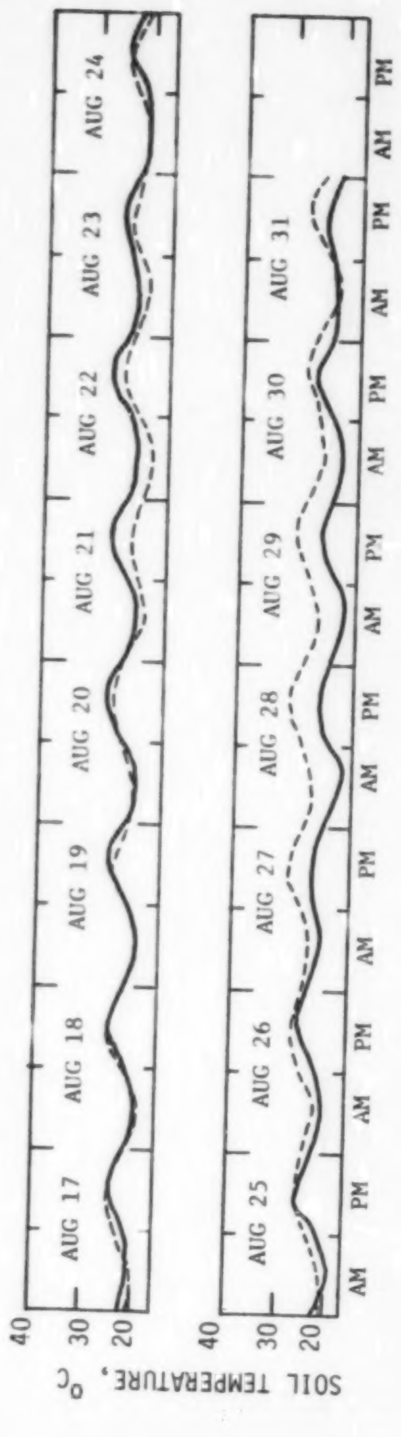


Figure 6.11 (Continued)

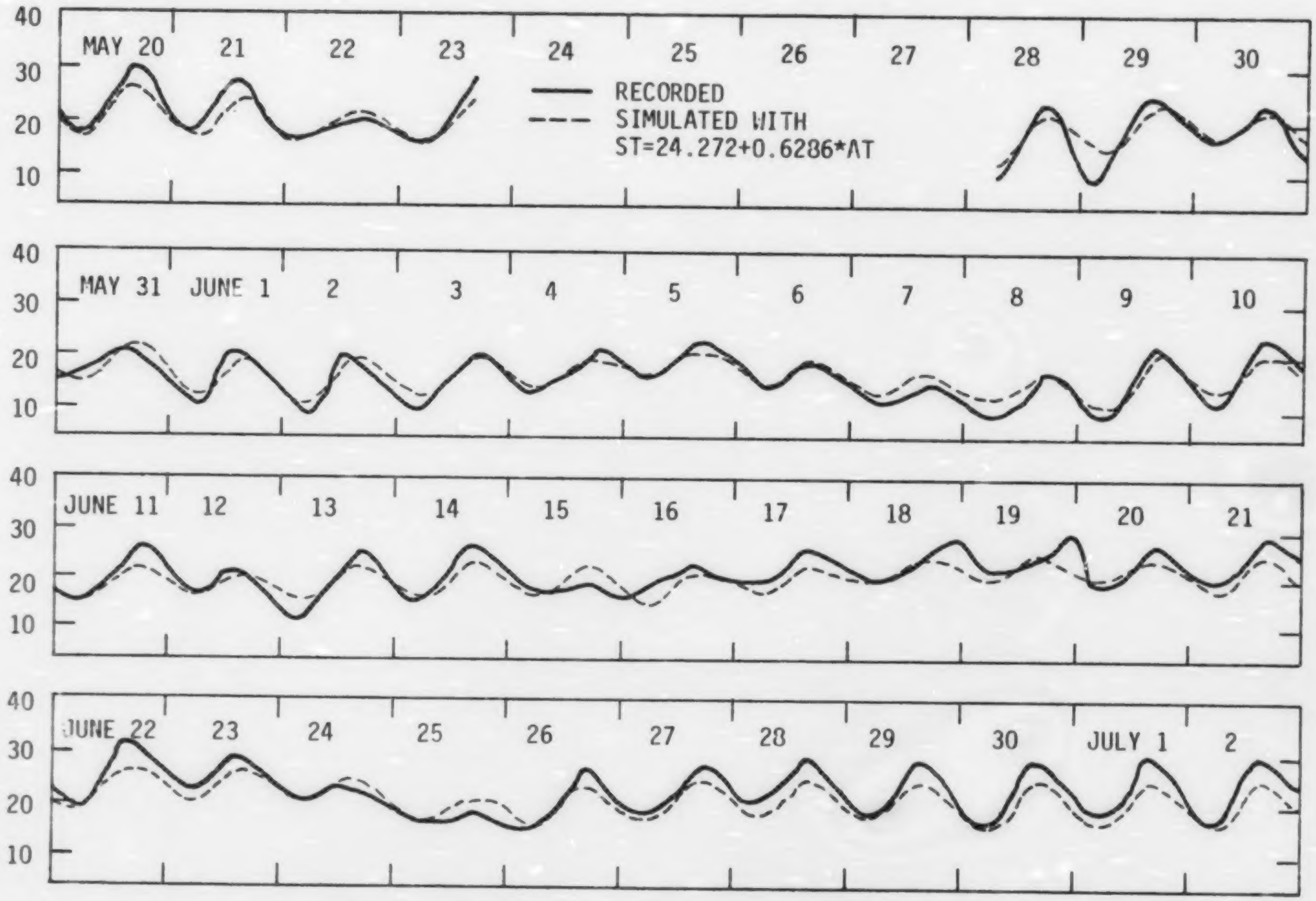


Figure 6.12 Upper zone temperature simulation at East Lansing, 1975 (continued)

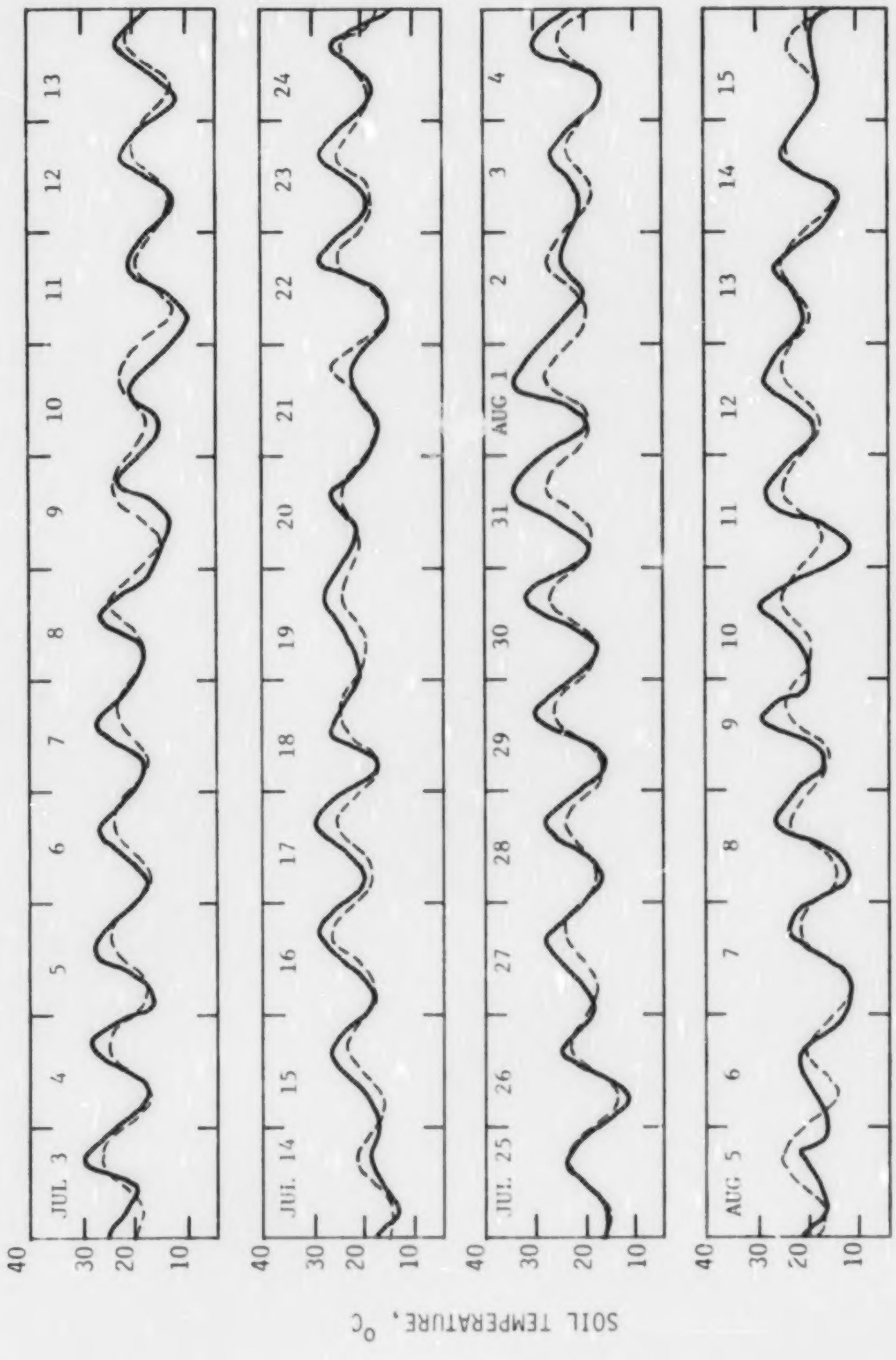


Figure 6.12 (Continued)

temperatures in both Georgia and Michigan were not based on air temperature since they are not considered very sensitive to diurnal fluxes, but are sensitive to seasonal fluxes. Daily average temperatures for these zones are simulated by interpolating average monthly soil temperature input values. Figure 6.13 shows that 60 cm soil temperatures at Watkinsville, Georgia varied no more than 3 Celsius degrees over a 2.5 month summer period. Figure 6.14 shows the seasonal variation of soil temperatures at 120 cm at East Lansing, Michigan. Monthly extremes are within 6 Celsius degrees of the monthly average.

Since the average temperatures of the lower and groundwater zone should be similar, the same simulated values were used for both of these zones. Lower zone monthly values for the Michigan watersheds were estimated from the values in Figure 6.12. For the Georgia watersheds monthly averages were not available for the nonsummer months so estimates for this period were made from Knoxville, Tennessee (1972-1974) 51 cm values. The values are given in Table 6.1.

The linear regression approach to soil temperature simulation currently used in the model is simple and practical. It appears adequate for simulating the summer growing season. However, refinement of the regression equation is needed for the nongrowing season and winter periods. Model users will need to develop the required temperature regression coefficients when the model is applied to watersheds in other geographical areas. In the future, a physically based model relating soil temperatures to watershed and meteorologic conditions should be implemented in the ARM Model.

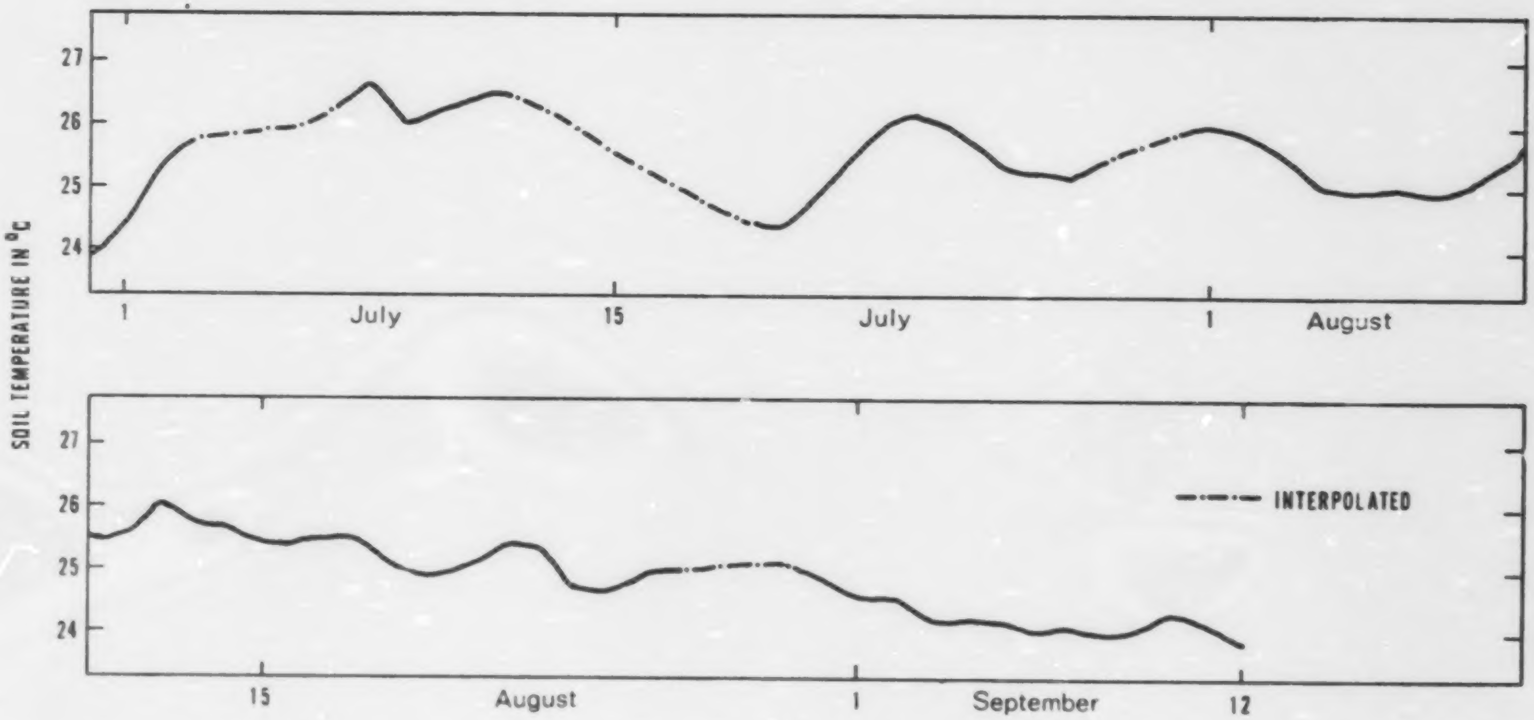


Figure 6.13 Soil temperature at 60 cm depth at Watkinsville, 1973

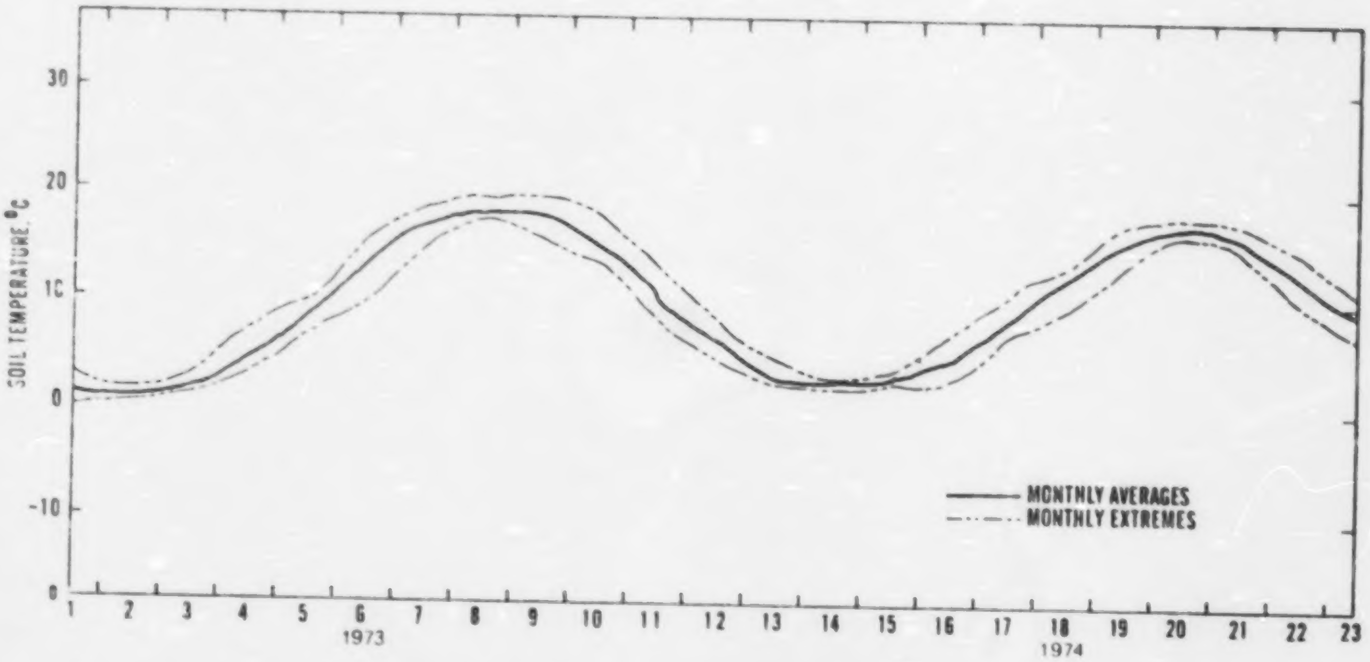


Figure 6.14 Soil temperature at 60 cm depth at East Lansing, January 1973-November 1974

TABLE 6.1 LOWER ZONE AVERAGE MONTHLY SOIL TEMPERATURES FOR THE TEST AREAS (°C)

Month	Watkinsville, GA	E. Lansing, MI
January	8.9	3.4
February	8.3	3.4
March	11.7	2.8
April	13.9	4.5
May	18.3	9.2
June	22.8	13.6
July	25.0	16.9
August	25.0	18.4
September	24.4	18.1
October	21.7	14.8
November	14.4	10.7
December	10.6	6.8

SECTION 7

SOIL PESTICIDE DEGRADATION SIMULATION

Decay or degradation of pesticides by biological and chemical processes is the major mechanism for the attenuation of pesticides on a watershed. Studies conducted by ERL-Athens have found that less than ten percent of the applied pesticides are lost via runoff (Smith et al., 1977). Thus, for many pesticides, e.g. diphenamid and atrazine, over 90 percent of what is applied is degraded in the soil. Since the amount of pesticide in the soil is the major factor in determining the amount available to runoff, an accurate simulation of pesticide degradation is vital to correctly simulate pesticide transport from a watershed. Consequently, alternative degradation simulation algorithms have been studied to determine the most accurate method of simulating pesticide decay that can be generally applied within the framework of the ARM Model.

As discussed in previous reports (Crawford and Donigian, 1973; Donigian and Crawford, 1976), the ARM Model initially used a first-order degradation algorithm. Pesticide decay was directly proportional to the amount of pesticide in the soil. For some pesticides (atrazine and diphenamid) the first-order decay rate was found to initially degrade the pesticide too slowly and then later in the season too quickly. In Figure 7.1 the relationship between the simulated and observed decay curves demonstrates this problem. Thus, for runoff events early in the crop season the amount of pesticide available for runoff was too great, while later in the season not enough was available. This made simulation of atrazine and diphenamid runoff difficult.

ALTERNATIVE DEGRADATION ALGORITHMS

Since the simple first-order degradation approach was not accurate enough for a good simulation of pesticide runoff other approaches were studied. One alternative was a first-order degradation algorithm corrected for the effects of soil moisture and temperature. This environmental approach (Steen, 1975) was derived from laboratory studies of diphenamid and was described as a subsurface degradation algorithm. However, in our evaluation we incorporated the algorithm into both the surface and upper zones. The equation for this approach is:

$$K = Kopt\ e^{(AK(Moist-Mopt)^2)}\, e^{(BK(Temp-Topt))} * \left[\frac{Tmax-Temp}{Tmax-Topt}\right] BK(Tmax-Topt) \qquad (7.1)$$

where K = actual degradation rate for the interval ($days^{-1}$)

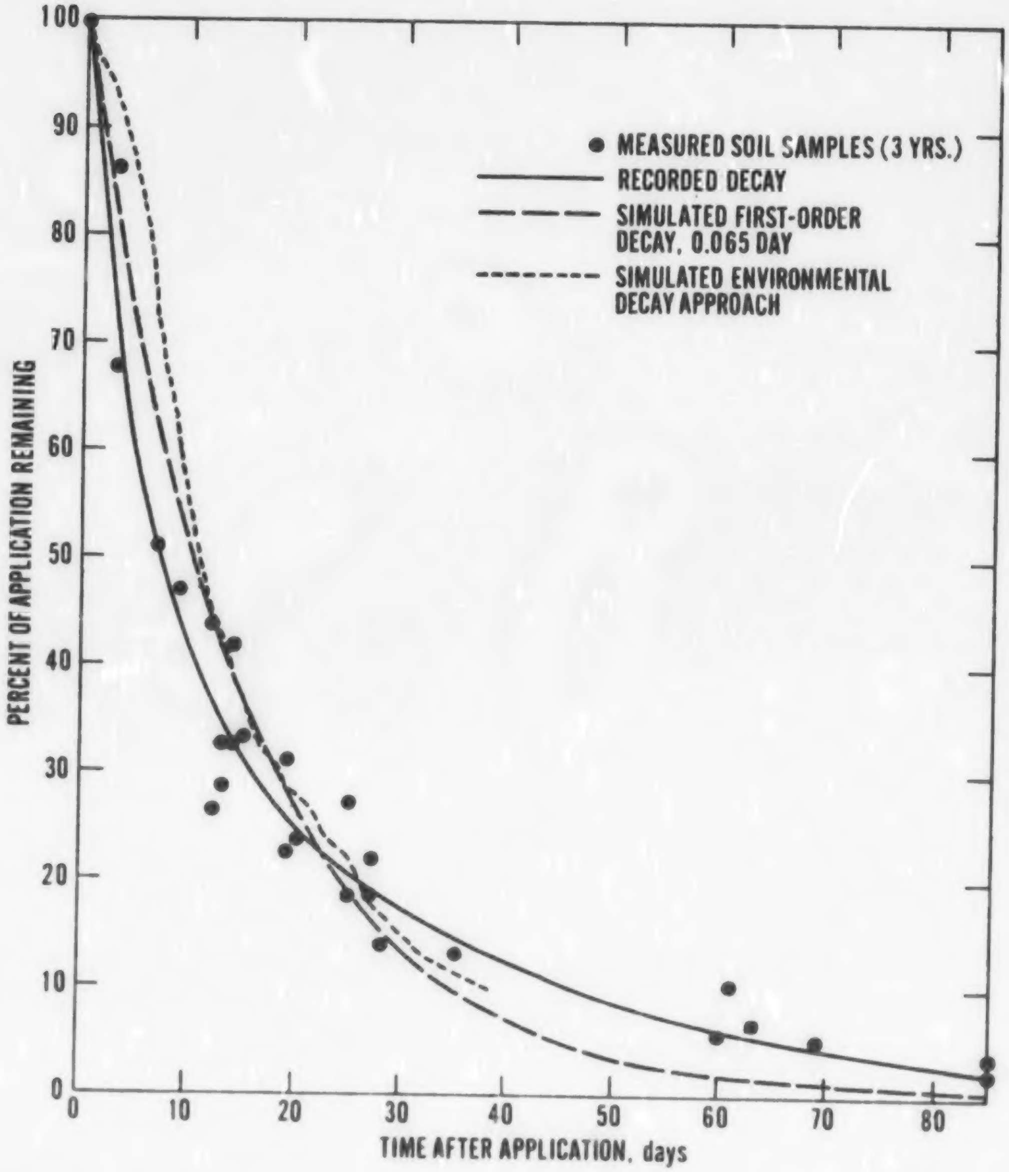


Figure 7.1 Comparison of atrazine degradation rates for the P2 watershed

Kopt = optimum degradation rate, day^{-1}
Mopt = optimum soil moisture content, percent by weight
Moist = actual or simulated soil moisture content for the interval, percent by weight
Tmax = maximum soil temperature at which biological degradation occurs, °C
Topt = optimum soil temperature, °C
Temp = actual or simulated soil temperature for the interval, °C
AK = constant
BK = constant

For diphenamid Kopt was found to equal 0.123 day^{-1}, Mopt equals 0.175, Tmax equals 40°C, Topt equals 35°C, AK equals -100, and BK equals 0.05.

As shown in Figure 7.2, the degradation rate is sensitive to changes in soil moisture and temperature. Thus, correctly modeling these influences (as discussed in Section 6) should provide a more accurate calculation of pesticide degradation than given by the simple first-order degradation approach. However, test results did not support this hypothesis. The

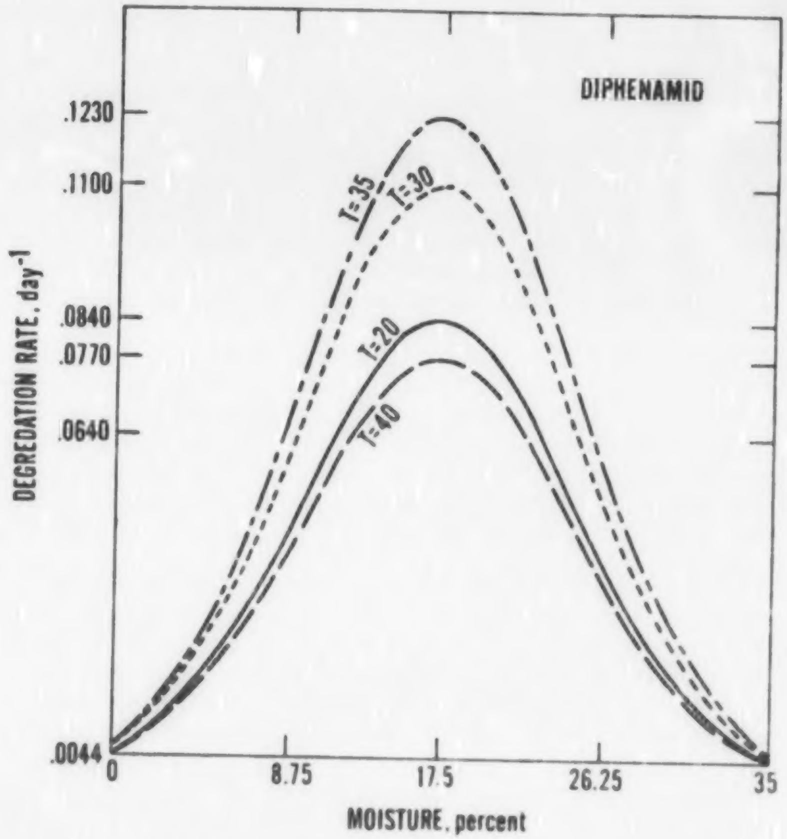


Figure 7.2 Environmental effects on dephenamid degradation rates

changes to the actual degradation rate, K, from the daily fluctuation of soil moisture and temperature proved to be relatively minor and deviated only slightly in the long run from the simple first-order degradation approach. This led to results similar to the simple first-order degradation approach.

A comparison of the simple first-order degradation approach and the environmental degradation approach (Figure 7.1) shows that the latter simulated the amount of degradation less accurately than the simple first-order approach in the period immediately after application. This early period is critically important in correctly determining the amount of pesticide runoff. The first significant runoff event after application usually removes the largest amount of pesticide for the season, because less pesticide is available for runoff as the season progresses. It is in this early period prior to the first runoff event that the environmental approach fails. Failure to correctly simulate pesticide degradation occurs because the environmental factors (soil moisture and temperature) are not at optimum conditions for biological decay in the surface zone where application occurs. Thus, degradation by biological processes is minimal as reflected by the high percent of application amount remaining in the soil (Figure 7.1). However, chemical processes (to be discussed below) are the dominating degradation component for this period and are not handled by the environmental degradation approach.

Sensitivity tests were conducted on the Steen equation (Equation 7.1). Daily max-min air temperature, which is used as input to the ARM Model, was changed by ± 10 Celsius degrees. In two sensitivity trials the resultant pesticide decay after application is changed only slightly from the base conditions. In the same manner soil moisture values were changed by ± 30 percent. This gives a greater change in response from the base conditions than seen in the temperature sensitivity tests, but still the changes are not substantially different from the base (Figure 7.3).

The relative insensitivity of the environmental degradation model to the daily fluctuations of soil moisture and temperature does not justify the required effort to simulate and incorporate the moisture and temperature effects. Also, the constants AK and BK will vary with pesticide characteristics and soil characteristics; they must be evaluated through calibration with recorded data. For these reasons the environmental approach has not been implemented in the current version of the ARM Model.

Detailed collection and analysis of atrazine remaining on the P2 watershed in the summer of 1975 provided enough data to develop a better understanding of the degradation processes. From this understanding a more accurate degradation algorithm than the first-order approach was developed. This new approach is the step-wise degradation algorithm. The ERL-Athens researchers found that for some pesticides (atrazine and diphenamid) the degradation rate changes substantially with the first major storm after application (Smith et al, 1976). Decay rate changes can be explained by existing soil conditions. Prior to the pesticide application the soil is loosely tilled. Tillage breaks up thermal and hydraulic conductance between the surface and subsurface soil layers. This enables the existence of sizable temperature

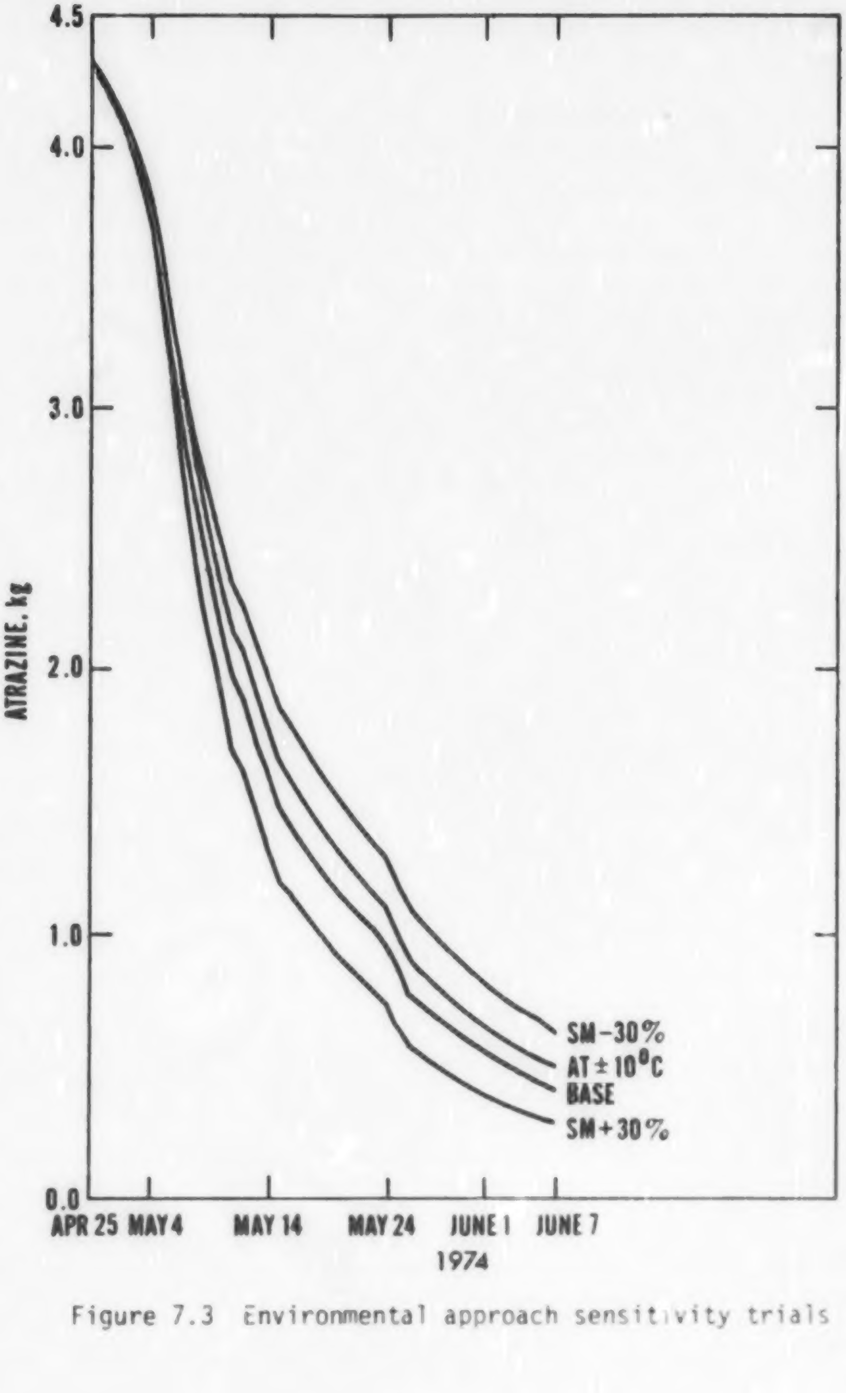


Figure 7.3 Environmental approach sensitivity trials

gradients near the soil surface, both relative to subsurface soil temperature and air temperature. For the first two or three days after pesticide application the surface soil temperature was 15 to 30 Celsius degrees hotter than the air temperature on P2. This gradient gradually decreased with time as the soil compacted. Then a rainstorm further compacted the surface layer, established strong conductance with the subsurface soils, and markedly decreased surface soil temperatures.

The high surface soil temperatures immediately after pesticide application result in pesticide degradation by chemical processes. This greatly diminishes once the surface soil temperature drops after a significant rainfall. At this point in time biological processes take over in playing the major role in pesticide degradation. The simple first-order approach and the more complex environmental approach by Steen fail in that they consider only biological decay. They cannot correctly represent the rapid decay caused by chemical processes without incorrectly representing the slower decay by biological processes. Both decays can be considered first-order mechanisms, but at significantly different reation rates. The step-wise degradation approach has the capability of reproducing the effects of more than one first-order decay rate during a crop season. Thus, both chemical and biological decay processes can be easily represented in the simulation of pesticide degradation.

SIMULATION RESULTS

As discussed previously, the simple first-order and environmental approaches to pesticide degradation give poor results. The step-wise approach gives good results. This is true for the simulation of atrazine on the P2 watershed for 1973 through 1975. A decay rate of 0.10 per day is used prior to the first runoff event after each application. After the first runoff event a decay rate of 0.04 per day is used. Figure 7.4 shows the simulated amount of atrazine in the soil from 1973 through 1975 respectively. The atrazine remaining in the soil is low in 1973 compared to measured soil samples. However, the same step-wise decay rates in 1974 and 1975 give excellent results. The low values in 1973 may result from a poor knowledge of the actual amount of atrazine applied that season. Disc filter monitoring of application rates in 1974 indicated that the amount of pesticide applied was 13 percent greater than the planned amount. A similar discrepancy would help to explain the 1973 results shown in Figure 7.4.

Paraquat, unlike atrazine and diphenamid, does not exhibit step-wise decay mechanisms; the simple first-order decay or a step-wise decay with the same decay rate at all times works reasonably well. Considering the variability in the recorded values, a constant decay rate of 0.002 per day adequately represents the decay of paraquat over long time spans, as is shown in Figure 7.5.

A study of the decay rates of atrazine and paraquat on the P6 watershed in Michigan shows some differences from the results on the P2 watershed. Atrazine was applied three times on the P6 watershed during the period of May 1974 through September 1975. From the few soil core samples taken

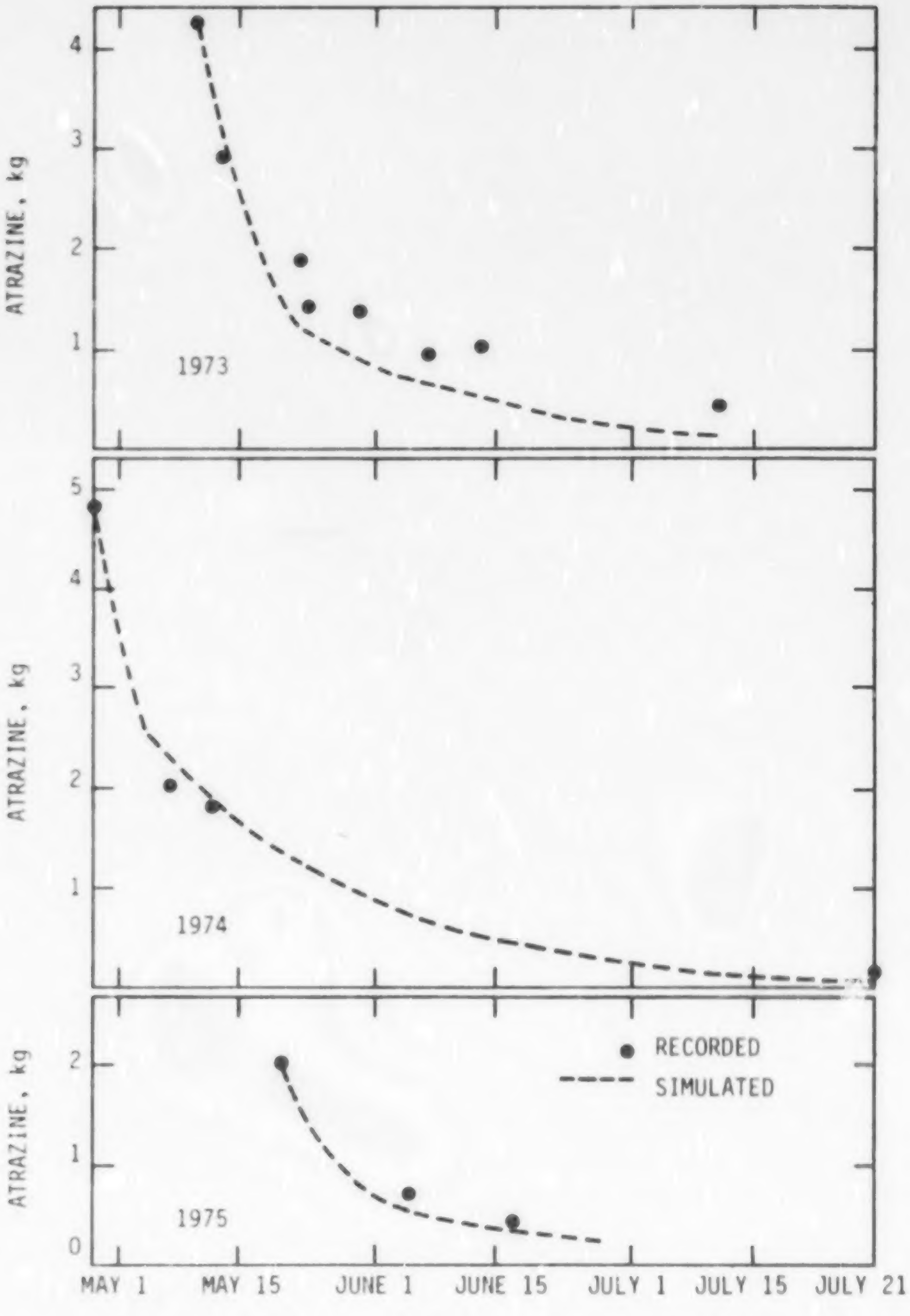


Figure 7.4 Atrazine in soil storage on the P2 watershed

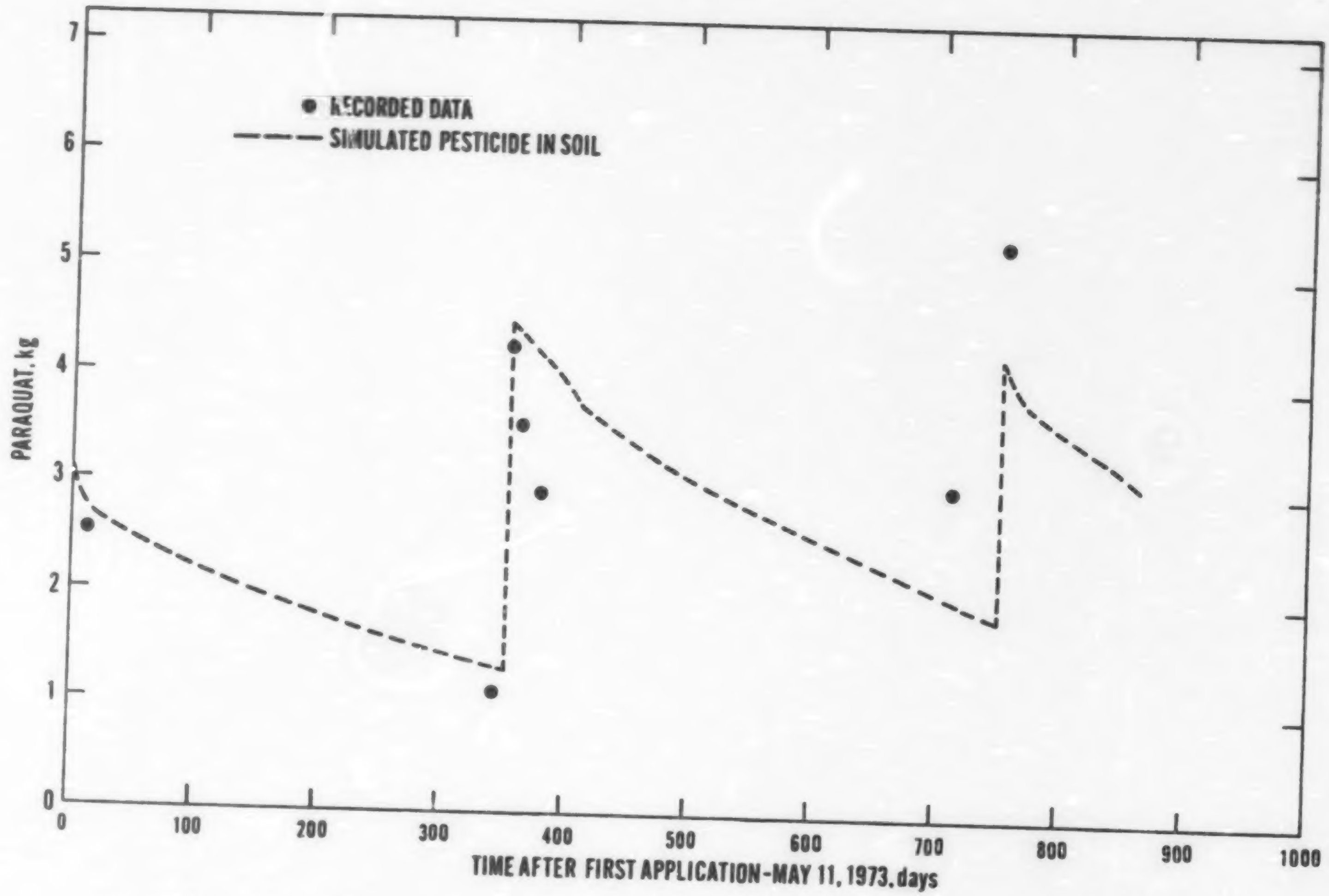


Figure 7.5 Paraquat in soil storage on the P2 watershed, 1973-1975

during this period it appears that chemical decay is a minor mechanism compared to biological decay. These results differ from those on the P2 watershed in Georgia and show the impact of different climatic regimes on the mechanisms controlling pesticide degradation. This observation is complicated, however, by the scarcity of measured soil core samples on the P6 watershed. Atrazine was measured on ten different dates during this 17 month period (Figure 7.6). The measured values all appear to be high; possibly as a result of problems in the sampling procedures. Similar questions are evident in the paraquat results shown in Figure 7.6. The recorded values in the 0 to 30 cm depth are so unusual and inconsistent that the actual rate of paraquat degradation can not be accurately determined. The amount of paraquat measured in the surface layer of soil (0-1 cm) is more consistent, but the actual values are impossible to explain except in terms of sampling problems. Thus, for the simulation of atrazine and paraquat on the P6 watershed degradation rates could not be calibrated because of discrepancies in the collected data. For atrazine it is assumed that biological decay is the only major degradation mechanism. A decay rate of 0.04 per day is used. For paraquat a constant decay rate of 0.002 per day is selected based on the assumption that the degradation rate will not differ substantially from that used on the P2 watershed. The inability to verify these assumptions makes good simulation results for atrazine and paraquat runoff from the P6 watershed difficult. This will be fully discussed in Section 10.

SUMMARY

The step-wise degradation approach works well for the pesticides studied. However, it is a simple approximation of chemical and biological processes at work in breaking pesticides down into other compounds. If the environmental degradation approach, described above, could better represent these processes (both chemical and biological) and have previously determined values for its input constants for all pesticides then it would be the preferable approach. In addition, if more long-term (multi-year) daily monitoring of pesticide mass and associated moisture and temperature values in the soil were made, a more accurate environmental approach could be developed. Further research in this and the better understanding of the chemical and biological decay processes would result in a more accurate pesticide degradation submodel.

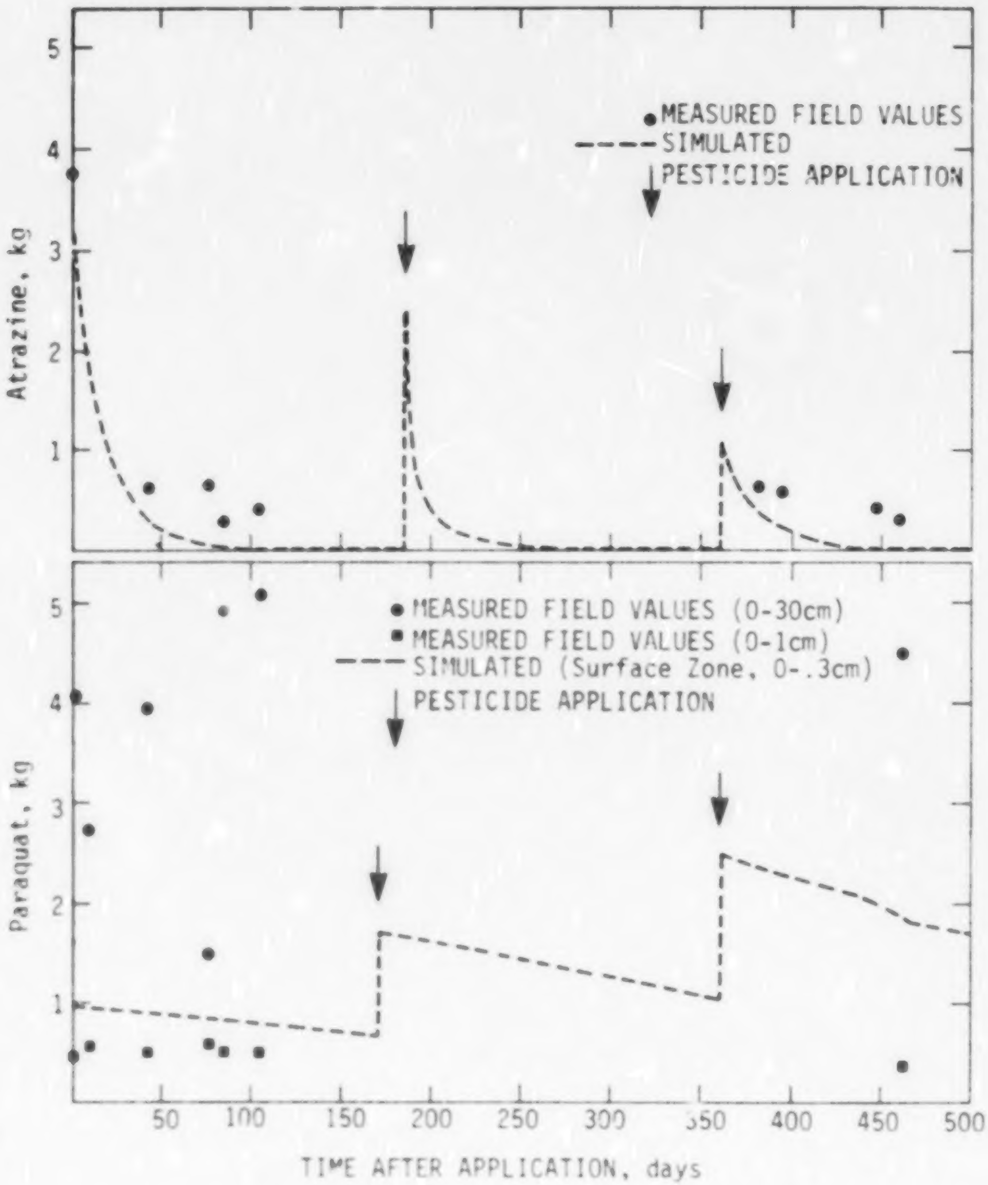


Figure 7.6 Atrazine and paraquat in soil storage on the P6 watershed, 1974-1975

SECTION 8

SOIL NUTRIENT SIMULATION

Nutrient modeling in the ARM Model involves the simulation of both soil nutrient storages and the transport or washoff of nutrients. Section 11 discusses the nutrient runoff simulation while this section discusses the simulation of soil nutrient storages and transformations. Beginning with a discussion of the major model changes since the last report (Donigian and Crawford, 1976), this section continues with a discussion on how optimum first-order reaction rates were obtained. The reaction rate values for the test watersheds are presented along with the soil nutrient storage simulation results. This section concludes with recommendations for future research and possible model improvements.

MAJOR MODEL CHANGES

During this project modifications were made to the nutrient model to simplify model operation and more accurately represent certain processes. The major changes to the nutrient model include:

(1) Elimination of certain transformation paths.
(2) Calculation of transformed nutrients as a function of soil water content and nutrient concentrations in each soil zone as opposed to nutrient mass.
(3) Simulation of plant uptake as a function of monthly uptake factors as opposed to crop canopy.

Transformation Processes

The changes in the transformation processes have been incorporated in Figure 4.5. The phosphorus transformations remain the same, but those for nitrogen were changed by combining the nitrite (NO_2) and nitrate (NO_3) forms. This resulted in the elimination of the reactions of NO_2 oxidation to NO_3 (K2 rate), and NO_3 reduction to NO_2 (KK2 rate). NO_2 was combined with NO_3 to simplify the model and to avoid using extremely large oxidation rates from NO_2 to NO_3. The NO_2 form could have been completely eliminated from the model since it is not persistant in most agricultural soils or in surface runoff due to rapid oxidation to NO_3. However, NO_2 remains in the model in the combined form (NO_2 + NO_3) in case it occurs in any future simulation work. Also, the combined form indicates that NO_2 is an intermediate step in the nitrification and denitrification processes. However, for most agricultural watersheds, the component of NO_2 plus NO_3 can be considered as NO_3.

One additional change in the nitrogen transformation processes was made; the nitrification reaction rate, K1, occuring from the adsorbed phase of ammonium (NH_4-A) was eliminated, because it has not been observed in laboratory tests (Davidson and Rao, 1976). Also, Mehran and Tanji's model (1974) of soil nitrogen transformations does not have a nitrification pathway from the adsorbed NH_4 form.

These changes are included in the summary of the reaction rate definitions in Table 8.1 and in the coupled system of differential equations in Table 8.2. Certain clarifications of these tables and Figure 4.5 need to be made. Plant nitrogen uptake occurs only in the NO_3 form since NO_2 is toxic to plants (Black, 1968). If persistant NO_2 occurs in the watershed, plant uptake should normally be reduced. Also, denitrification rates in the literature based on NO_3 will be larger than the input denitrification rate in the model, KD, since KD is based on the amounts NO_2 plus NO_3. Finally, the N_2 form represents any form of denitrified nitrogen in the gaseous form, including nitrous oxides.

Nutrient Transformation Calculations

Nutrient transformations were previously based on the nutrient mass in each soil zone, but were changed in this project to being based on the nutrient mass per mass of soil or soil water in each zone. Except for the groundwater zone, transformations were calculated in terms of kilograms per hectare of each nutrient form in each zone. Since the surface, upper, and lower zones have specified depths, the reactions were previously based on the nutrient mass per total volume of the zone, i.e. a volume-based concentration. The groundwater zone has no specified depth so the transformations were based merely on kilograms per hectare. The use of concentrations based on mass not volume is considered more theoretically consistent with first-order reaction rates. Most of the literature on adsorption/desorption reports reaction rates based on concentration on the soil mass and soil water mass. Plant uptake rates are also typically based on nutrient concentration in the soil water.

The reaction rates in the model were changed to a mass concentration basis for all the zones except the groundwater zone; the groundwater zone tranformations remain in terms of kg/ha. The NH_4 desorption rate, KAS, is now based on the concentration of adsorbed NH_4 on the soil mass. Likewise the nitrogen mineralization rate, KAM, is based on the organic nitrogen mass per soil mass. The PO_4 desorption rate, KAS, and the mineralization rate, KM, are also respectively based on the concentration of adsorbed or combined PO_4, and organic phosphorus per soil mass. All the other reaction rates are based on the mass of the nutrient per mass of soil water in the zone.

Additional model changes were made for calculating the soil and water masses. Soil bulk densities are now specified separately for each soil zone. The bulk densities and the volume of the zone are used to calculate the soil mass. The LANDS program calculates the moisture stored in each soil zone during each time interval for the hydrology simulation. The moisture values are then used in the nutrient model to evaluate nutrient

TABLE 8.1 DEFINITION OF N AND P REACTION RATES

Rate	Definition
Nitrogen	
K1	Nitrification rate of ammonium in solution (NH_4-S) to nitrite and nitrate (NO_2+NO_3)
KD	Denitrification rate of nitrite and nitrate to gaseous nitrogen (N_2)
KPL	Uptake rate of nitrate (and nitrite) by plants (Plnt-N)
KAM	Mineralization or ammonification rate of organic nitrogen (Org-N) to ammonium in solution
KIM	Immobilization rate of ammonium in solution to organic nitrogen
KKIM	Immobilization rate of nitrate to organic nitrogen
KSA	Exchange rate of ammonium from solution to adsorbed phase (NH_4-A)
KAS	Exchange rate of ammonium from adsorbed phase to solution
Phosphorus	
KM	Mineralization rate of organic phosphorus (Org P) to solution phosphate (PO_4-S)
KIM	Immobilization rate of solution phosphate to organic phosphorus
KPL	Uptake of solution phosphate by plants (Plnt-P)
KSA	Adsorption or combining of solution to adsorbed or combined phase (PO_4-A)
KAS	Desorption or dissolving or adsorbed or combined phase to solution phosphorus

note: All rates are based on the N or the P amounts of the form.

TABLE 8.2 COUPLED SYSTEM OF DIFFERENTIAL EQUATIONS FOR NITROGEN TRANSFORMATIONS

Organic Nitrogen:

$$\frac{d}{dt}(\mathrm{ORG\text{-}N}) = \mathrm{KIM}\,(\mathrm{NH_4\text{-}S}) + \mathrm{KKIM}\,(\mathrm{NO_3+NO_2}) - \mathrm{KAM}\,(\mathrm{ORG})$$

Solution Ammonia:

$$\frac{d}{dt}(\mathrm{NH_4\text{-}S}) = \mathrm{KAM}\,(\mathrm{ORG\text{-}N}) - (\mathrm{KSA} + \mathrm{KI} + \mathrm{KIM})(\mathrm{NH_4\text{-}S}) + \mathrm{KAS}\,(\mathrm{NH_4\text{-}A})$$

Adsorbed Ammonia:

$$\frac{d}{dt}(\mathrm{NH_4\text{-}A}) = \mathrm{KSA}\,(\mathrm{NH_4\text{-}S}) - \mathrm{KAS}\,(\mathrm{NH_4\text{-}A})$$

Nitrate:

$$\frac{d}{dt}(\mathrm{NO_3+NO_2}) = \mathrm{KI}\,(\mathrm{NH_4\text{-}S}) - (\mathrm{KD} + \mathrm{KKIM} + \mathrm{KPL})\,(\mathrm{NO_3+NO_2})$$

Nitrogen Gas:

$$\frac{d}{dt}(\mathrm{N_2}) = \mathrm{KD}(\mathrm{NO_3+NO_2})$$

Plant Nitrogen:

$$\frac{d}{dt}(\mathrm{PLNT\text{-}N}) = \mathrm{KPL}(\mathrm{NO_3+NO_2})$$

concentrations and transformations. Hence, reasonable simulation of the soil water storages, especially in the upper and lower zones, is needed for reliable transformation simulation.

In the model the soil moisture storage value in the upper zone is specified by UZS. It is the primary moisture component for upper zone transformations during nonstorm days. During storm days, UZS is augmented by the interflow component and infiltrating moisture that passes through the upper zone. UZS is primarily dependent upon the rainfall, evapotranspiration, and the input nominal upper zone storage value (UZSN). Care must be taken to use reasonable values for UZSN with regard to the depth of the upper zone so that realistic upper zone moisture values are simulated. All nutrient transformations in the model are discontinued at very low moisture values, which are not uncommon when very low UZSN values (less than 2 mm) are used. Nutrient transformations are inhibited at low moisture levels because some minimum moisture content is generally required as a medium for transformations. Black (1968) discusses the decrease in plant uptake, mineralization, and nitrification in dry soils. This same stopping of transformations in the model also occurs in the lower and surface zones at low moisture values. However, the lower zone soil moisture almost never reaches this level, and the surface zone moisture is always zero except when runoff is occurring. Hence, surface zone transformations do not occur except during storm events. This makes the surface zone a conceptually stable zone for the nutrient model. Such a stable zone has the advantage of simpler application; the amount and concentration of soil-associated nutrients available for erosion are relatively constant. A disadvantage is that a more active simulation of the surface zone may be needed for simulating soluble nutrients. Further testing of the model will determine this.

Groundwater transformations are performed in the model in the same manner as described in the previous report. The reactions are still based on mass of nutrients per area. The total groundwater is not simulated, and the depth and bulk density of the groundwater zone are not typically known. So it was considered undesirable to change the basis for groundwater transformations. A highly sophisticated model is needed to accurately simulate groundwater movement, transport, and transformations of chemicals.

Plant Uptake

Simulation of crop uptake of nutrients is important to soil nutrient simulation since it usually removes more nutrients from the soil system than any other process. To improve the ARM nutrient model, crop uptake was changed from being based on crop cover to being based on a user-specified uptake factor. Uptake by the crop was based on the monthly fraction of the cover which is an input factor. The previous algorithm was:

$$KPL = KPL_{max} * COVER \tag{8.1}$$

where KPL = plant uptake reaction rate, day^{-1}
$COVER$ = crop canopy fraction for the watershed
KPL_{max} = maximum rate of plant uptake, day^{-1}

However, further analysis of nitrogen uptake curves, such as those of Viets (1965), show uptake to occur most during periods of rapid growth and not when the crop canopy was fullest. Hence, to improve plant uptake simulation an input factor of monthly uptake was introduced. Separate monthly uptake factors for the lower zone and upper layers (surface and upper zones) were added to the model. These factors work basically the same as the COVER factor. The new algorithm is:

$$KPL = KPL_{max} * UPTK \qquad (8.2)$$

where UPTK = average fraction of maximum uptake occurring during a month

Figure 8.1 compares the previous method (Equation 8.1) of distributing plant uptake using COVER and the new method using the uptake factor (Equation 8.2). The actual uptake is approximated from Figure 15 of Viets (1965) and from personal communication with Boyd Ellis (1976) of Michigan State University. The old method has the maximum uptake occurring in August and September when the plant is fully grown, while the new method has maximum uptake occurring in July. The major part of the uptake would come from the upper zone in June and early July and from the lower zone in late July and early August.

EVALUATING NUTRIENT REACTION RATES

Optimum nitrogen and phosphorus transformation reaction rates are input to the nutrient model. They are the main factors influencing simulation of soil nutrient storages. Each reaction rate is specified for each soil zone. These reaction rates are optimum at 35°C and above, and at lower soil temperatures the rates are reduced according to a simplified Arrhenius Equation. The procedure used for evaluating reaction rates and temperature coefficients was to search the literature for initial estimates and then adjust these values by calibration on observed soil storage and runoff data.

The most comprehensive literature found applicable to field conditions was that of Stanford and Smith (1972). They determined nitrogen mineralization rate constants for 39 widely differing soils. The mineralization rates did not significantly differ among the soils. These rates were based on mineralizable N, so an estimate of the mineralizable N in the soil was made as a fraction of Total N. Rather than change the input storage values to potentially mineralizable N, the literature rates were lowered by the mineralizable N estimate. These rates for each watershed tested were used for mineralization of both organic nitrogen (KAM) and phosphorus (KM). They were considered the most reliable rates and were not changed during the calibration process. These are also net mineralization rates so immobilization rates were set to zero.

Other literature (Mirsa, et al., 1974; Starr, et al., 1974; Mehran and Tanji, 1974) was not nearly as comprehensive for field conditions, but was useful in determining initial rate values and relative magnitudes. Reaction rates obtained for particular soils gave indications of the magnitude of initial nitrification rates (K1) and NH_4 exchange (KSA and KSA). The cation exchange capacity also provided an estimate of the extent of NH_4 adsorption.

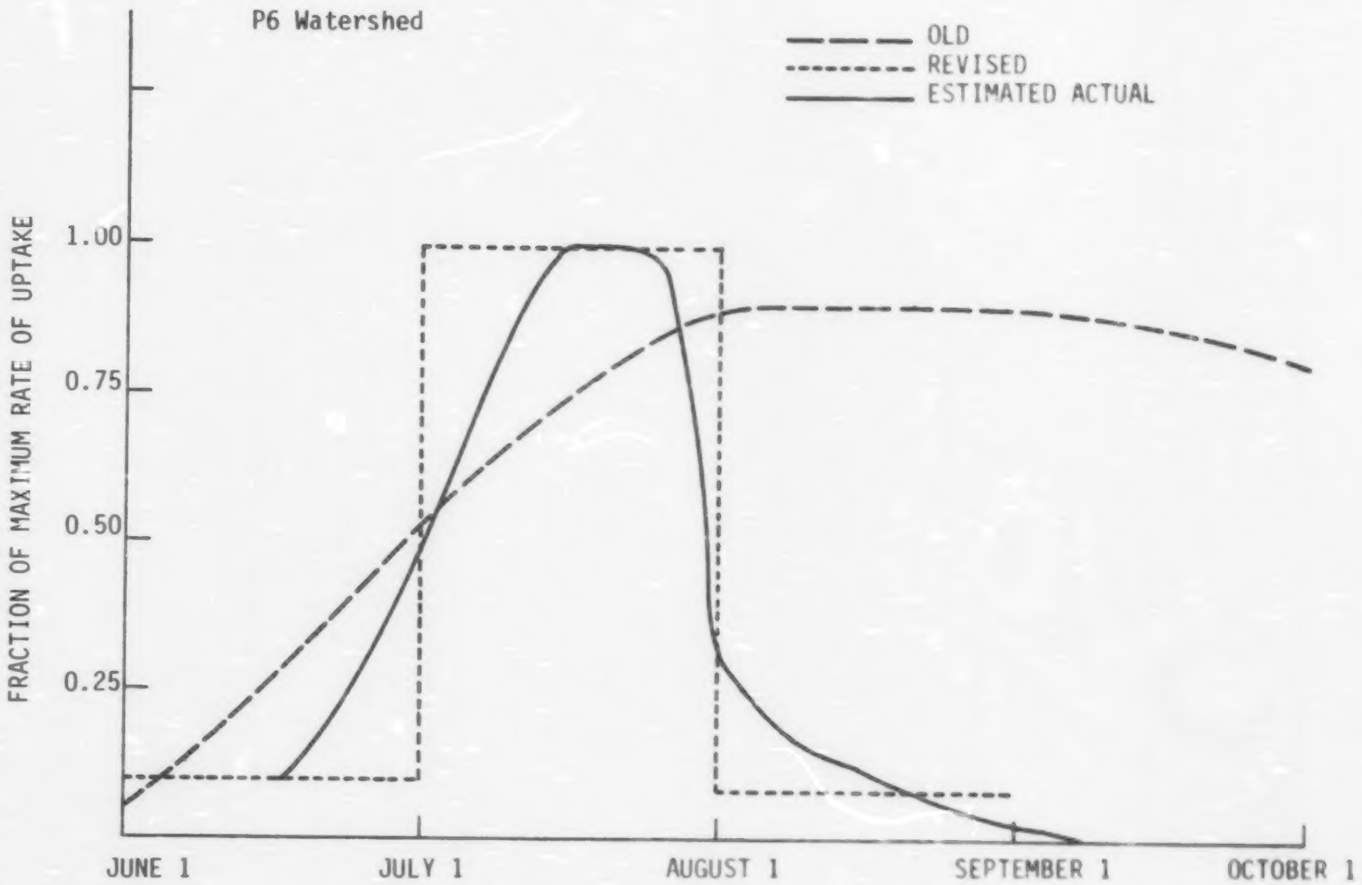


Figure 8.1 Comparison of plant uptake functions

Research done by nutrient modelers at the University of Florida also provided information on the magnitude and sensitivity of reaction rates (Rao, et al., 1976a; Mansell, et al., 1976).

Quantitative relationships for the effect of temperature on nitrogen transformations were more prevalent in the literature. The temperature relationship for nitrification and denitrification was obtained from the modeling work of Hagin and Amberger (1974). The mineralization rate temperature coefficient was determined from data of Stanford, et al. (1973) and compared with Hagin and Amberger (1974). The plant uptake rate temperature coefficient was determined from data of Van Den Honert and Hooymans (1955). The adsorption/desorption rates coefficient values were estimated from the other values and soil water viscosity. The corresponding nitrogen coefficients were also used for phosphorus.

The same temperature coefficients were used for each watershed and remained unchanged throughout the calibration period. However, many of the reaction rates were calibrated to the specific conditions of each test watershed. The plant uptake rate, KPL, was adjusted to obtain desired results since no rate data was found in the literature for these field conditions. KPL was adjusted to produce plant uptake in the range of values estimated for the growing season. The distribution of seasonal crop uptake was estimated from observed data of plant growth and distributed by the inputted monthly fraction of maximum uptake. The month with the most growth was assumed to have the maximum uptake occurring at the input optimum rates; thus, that monthly uptake factor was 1.0. The values used are in Table 8.3. Different values were used each year of simulation due to different crop growth rates.

The observed soil nutrient storages and nutrient runoff values were used to calibrate the less certain reaction rates. The proportion of NH_4 to NO_3 was directly regulated by K1, as well as indirectly by KSA and KAS. Particular attention was given to the upper and surface zone rates since these zones have a greater effect on the simulated nutrients in the runoff from the small test watersheds. Small values of KD were introduced to lower the excess simulated nitrogen in the soil after the desired plant uptake amount was satisfied. Broadbent and Clark (1965) estimated 10 to 15 percent of the annual mineral nitrogen input to agricultural areas is lost by denitrification. PO_4 exchange rates KSA and KAS were estimated from the amounts observed in the runoff.

Table 8.4 contains the reaction rates used in the test watersheds. These values were calibrated on the runoff results as well on soil storage values, so they may not be directly applicable to pure soil transformation studies. However, they are generally within the range of such values in the literature. Since the surface zone transformations occur only during storm events the rate values should be evaluated with that taken into account. The surface exchange and mineralization rates were adjusted to produce the simulated amounts of NH_4 and PO_4 in the runoff.

TABLE 8.3 FRACTION OF MAXIMUM MONTHLY PLANT UPTAKE OF NUTRIENTS USED IN THE MODEL FOR THE P2 AND P6 WATERSHEDS

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
P2 Watershed												
1974												
Upper layers	.20	.20	.20	.20	.15	.75	.20	.07	0	0	.20	.20
Lower zone	.20	.20	.20	.20	.03	.55	.45	.10	0	0	.20	.20
1975												
Upper layers	.20	.20	.20	.20	0	.90	1.0	.05	0	0	.20	.20
Lower zone	.20	.20	.20	.20	0	.80	1.0	.10	0	0	.20	.20
P6 Watershed												
1974												
Upper layers	0	0	0	0	0	.09	1.0	.06	0	0	0	0
Lower zone	0	0	0	0	0	.01	1.0	.125	0	0	0	0
1975												
Upper layers	0	0	0	0	0	1.0	.50	.05	0	0	0	0
Lower zone	0	0	0	0	0	.30	.75	.055	0	0	0	0

TABLE 8.4 NUTRIENT REACTION RATES FOR THE P2 AND P6 WATERSHEDS

P2 WATERSHED								
Nitrogen Rates (day^{-1})	K1	K2	KPL	KAM	KIM	KKIM	KSA	KAS
Surface	1.000	.0000	.1000	.0000	.0000	.0000	1.0000	.2000
Upper Zone	.2000	.0060	.1300	.0020	.0000	.0000	1.0000	.2500
Lower Zone	.1000	.0020	.0250	.0020	.0000	.0000	1.0000	.2000
Groundwater	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Temperature Coef.	1.050	1.070	1.070	1.070	1.070	1.070	1.050	1.050
Phosphorus Rates (day^{-1})	KM	KIM	KPL	KSA	KAS			
Surface	.0200	.0000	.0100	1.0000	.0150			
Upper Zone	.0020	.0000	.7000	1.0000	.0015			
Lower Zone	.0020	.0000	.8000	1.0000	.0050			
Groundwater	.0000	.0000	.0000	.0000	.0000			
Temperature Coef.	1.070	1.070	1.070	1.050	1.050			
P6 WATERSHED								
Nitrogen Rates (day^{-1})	K1	KD	KPL	KAM	KIM	KKIM	KSA	KAS
Surface	3.000	.0000	.2500	.0150	.0000	.0000	5.000	.7500
Upper Zone	1.2500	.0500	.4000	.0015	.0000	.0000	.7500	.3000
Lower Zone	.7000	.0000	.0900	.0015	.0000	.0000	1.0000	.4000
Groundwater	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Temperature Coef.	1.050	1.070	1.070	1.070	1.070	1.070	1.050	1.050
Phosphorus Rates (day^{-1})	KM	KIM	KPL	KSA	KAS			
Surface	.0150	.0000	.0100	1.0000	.0100			
Upper Zone	.0015	.0000	2.1000	.5000	.0060			
Lower Zone	.0015	.0000	1.7000	.5000	.0050			
Groundwater	.0000	.0000	.0000	.0000	.0000			
Temperature Coef.	1.070	1.070	1.070	1.050	1.050			

SOIL NUTRIENT SIMULATION RESULTS

The reaction rates in Table 8.4 were used in the simulation of soil nutrient storages. The nutrients stored in the surface and upper zones are the primary sources of nutrients in surface runoff (Section 11). The soil storage results for the P2 watershed are presented in Figures 8.2 and 8.3. Figure 8.2 contains the surface zone and upper zone soil storages of total Kjeldahl nitrogen (TKN = ORGANIC N + NH_4-N) and NO_3-N. The observed values are calculated from composite areal samples taken from the surface to 7.5 cm depth. They correspond to the simulated surface zone plus upper zone results. The surface zone results are for the top 3.2 mm. Due to the shallowness of this zone no observed values were taken or estimated. Figure 8.3 provides the corresponding lower zone soil storages. The observed values are also from composite areal and depth samples for 7.5 cm to 190 cm. The 152 cm to 190 cm component of these observed values was estimated. Figure 8.4 gives merely the simulated solution PO_4-P and Organic P results since no observed data was available. On the P2 watershed, a single set of reaction rates was calibrated for both the 1974 and 1975 growing seasons.

Soils were not sampled as deeply for the P6 watershed as for P2, so only surface zone and upper zone results are presented for P6. However, more nutrient forms were analyzed. Figure 8.5 presents the NO_3-N and the Available P results while Figure 8.6 contains the NH_4 and Organic N results. The observed values again are from composite areal samples from the surface to 7.5 cm depth and correspond to the upper zone plus surface zone values. The P6 watershed was calibrated on the period of May 22, 1974 through September 30, 1974. The calibrated reaction rates were then used to simulate the 1975 growing season, June 1 through September 30; however, the soil storage, plant uptake, and the soil temperature regression constants input values were all reset. After the summer 1975 results proved satisfactory, a single run was made from May 22, 1974 through May 8, 1975. The pronounced peaks of the upper and surface zone storage of both watersheds are the result of fertilizer applications (Table 8.5). Unless NO_3 was applied directly, the NO_3 peak rose slowly after the fertilizer NH_4 had been oxidized.

The simulation of soil nutrients requires the input of initial soil nutrient storages (Table 8.6) which correspond to the starting values in Figures 8.3-8.6. The Available P values include both solution and adsorbed PO_4. The initial values for the upper zone and lower zone nutrient forms that were not analyzed were estimated from other forms analyzed, data from related soil series in the area, prior data analyzed from the watershed, prior fertilizer applications, or observation of runoff results. The lower zone estimates were not considered as crucial as the upper zone values since that zone does not directly influence the nutrients measured in the surface runoff from these small test watersheds. However, the initial surface zone values are critical to the nutrients simulated on the sediment, namely the organic and adsorbed forms of nitrogen and phosphorus. These values were obtained by averaging the observed concentration on the runoff sediment.

The other major nutrient storage value is that of plant uptake and storage. Corn (Zea mays L.) was planted both years on both watersheds. The crop

TABLE 8.5 N AND P FERTILIZER APPLICATIONS

WATERSHED	DATE	FORM APPLIED	N (kg/ha)	P (kg/ha)	MEANS OF APPLYING
P2	4-29-74	sulphate of ammonia	38	33	incorporated pellets
	6-11-74	50% urea, 50% ammonia	101	-	spray, sidedressed
	4-24-75	ammonium nitrate, superphosphate	22	21	incorporated pellets
	6-25-75	50% urea, 50% ammonia	112	-	spray, sidedressed
P6	5-20-74	ammonium nitrate, monocalcium phosphate	68*	93*	incorporated pellets
	7-8-74	ammonium nitrate	130*	-	sidedressed
	11-7-74	ammonium nitrate	130*	-	no incorporation, pellets broadcasted
	5-16-75	ammonium nitrate, monocalcium phosphate	68*	131	incorporated pellets
	6-25-75	ammonium nitrate	64*	-	sidedressed

* delivered application rate

TABLE 8.6 INITIAL SOIL STORAGES AND BULK DENSITIES

WATERSHED and DATE	ZONE	BULK DENSITY g/cm	ORG-N	NH_4-N (sol)	NH_4-N (ads)	NO_3	ORG-P (sol)	PO_4-P (sol)	PO_4-P (ads)
			kg/ha						
P2 5-1-74	surface	1.6	100.9	2.24	22.42	2.24	13.45	1.12	40.35
	upper	1.6	420.3	4.48	44.84	3.36	112.1	0.39	341.8
	lower	1.6	2802.	6.73	22.42	237.6	896.6	1.12	151.3
P2 5-10-75	surface	1.6	22.42	0.22	6.16	0.57	23.54	0.0	44.83
	upper	1.6	479.7	4.48	48.83	13.20	112.1	0.34	336.2
	lower	1.6	2690.	6.72	22.42	213.0	896.6	40.35	112.1
P6 5-22-75	surface	1.02	76.2	0.45	1.12	2.19	30.3	0.10	7.44
	upper	1.16	571.6	8.97	22.98	30.71	196.1	14.90	113.5
	lower	1.59	2339.	10.09	25.78	112.1	1121.	30.0	270.7
P6 6-1-75	surface	1.02	77.3	0.22	1.02	0.34	45.95	1.46	2.91
	upper	1.16	493.2	4.81	11.21	22.30	246.6	1.52	125.1
	lower	1.59	1667.8	22.4	56.04	170.4	896.6	22.42	224.2

notes: sol - solution form
ads - adsorbed form

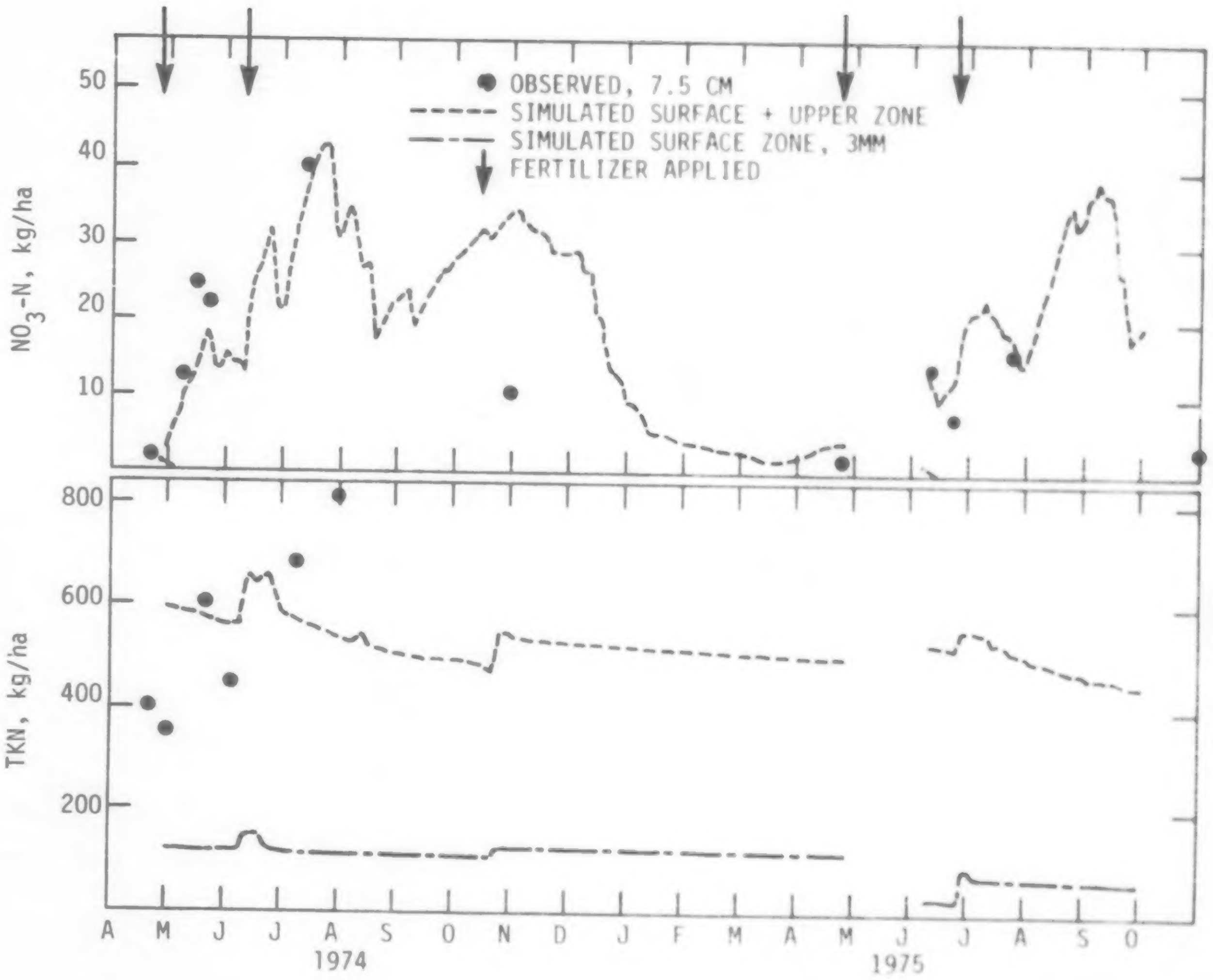


Figure 8.2 NO_3 and TKN in surface and upper zone storage on the P2 watershed

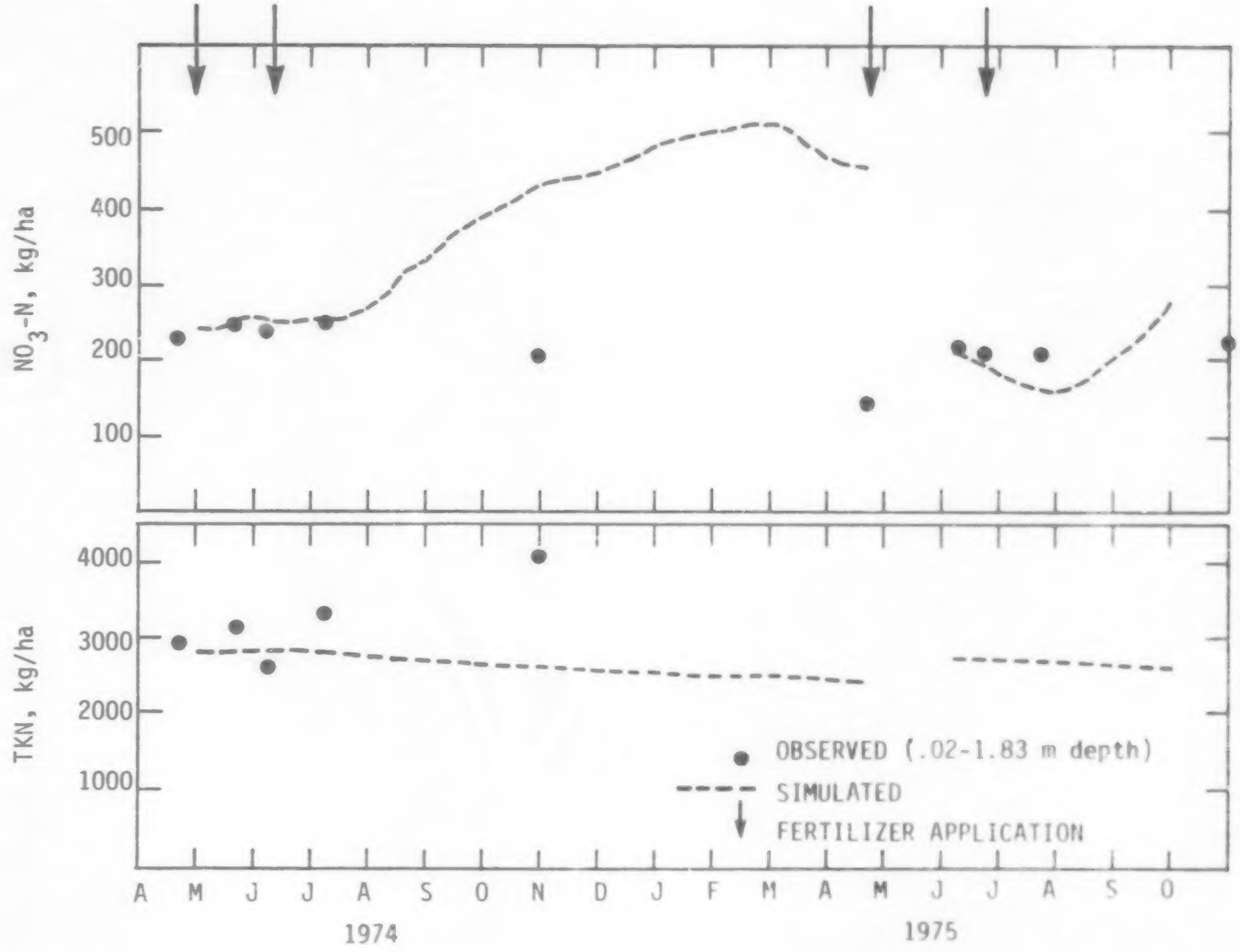


Figure 8.3 NO$_3$ and TKN in lower zone storage on the P2 watershed

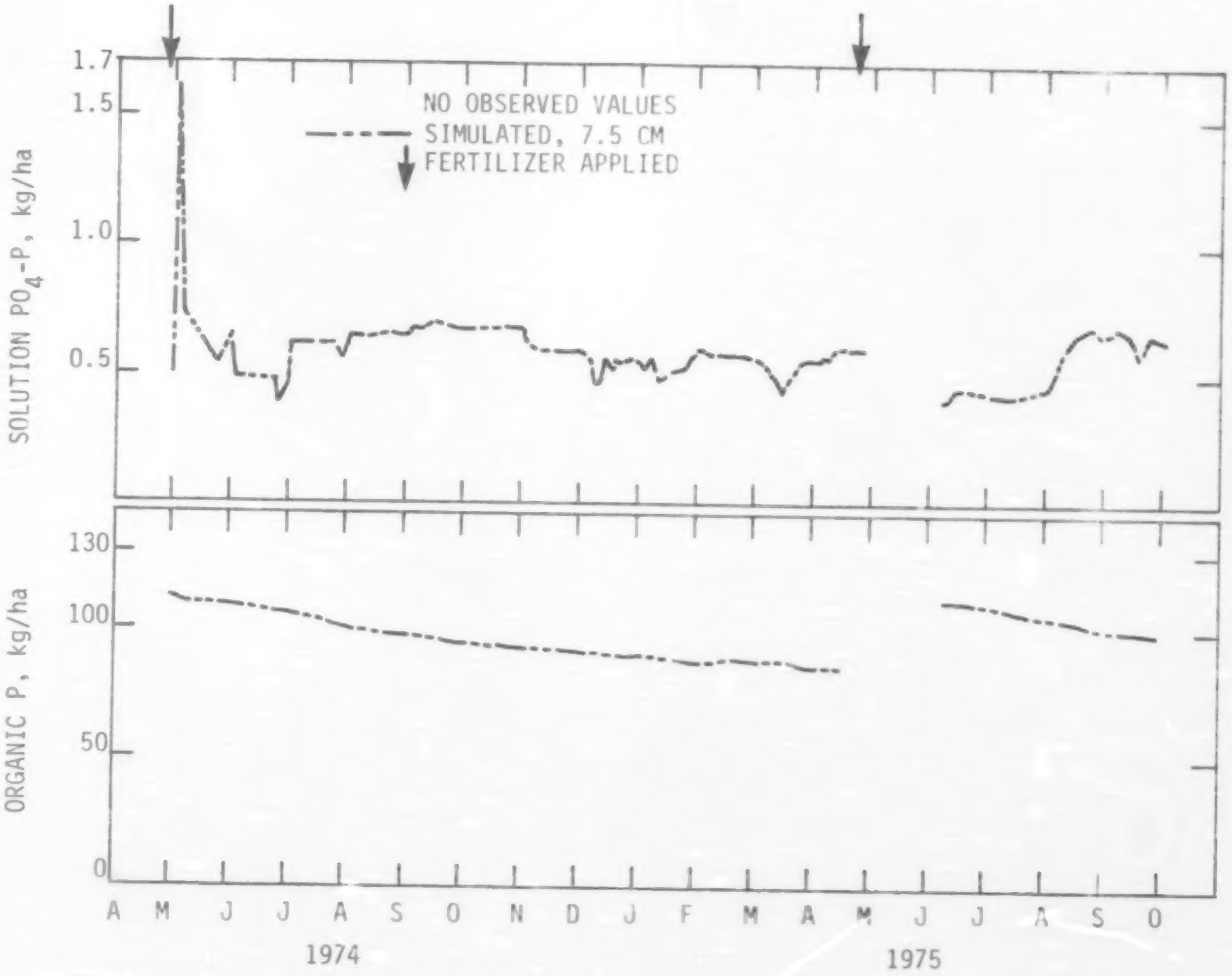


Figure 8.4 PO_4 and organic P in upper zone storage on the P2 watershed

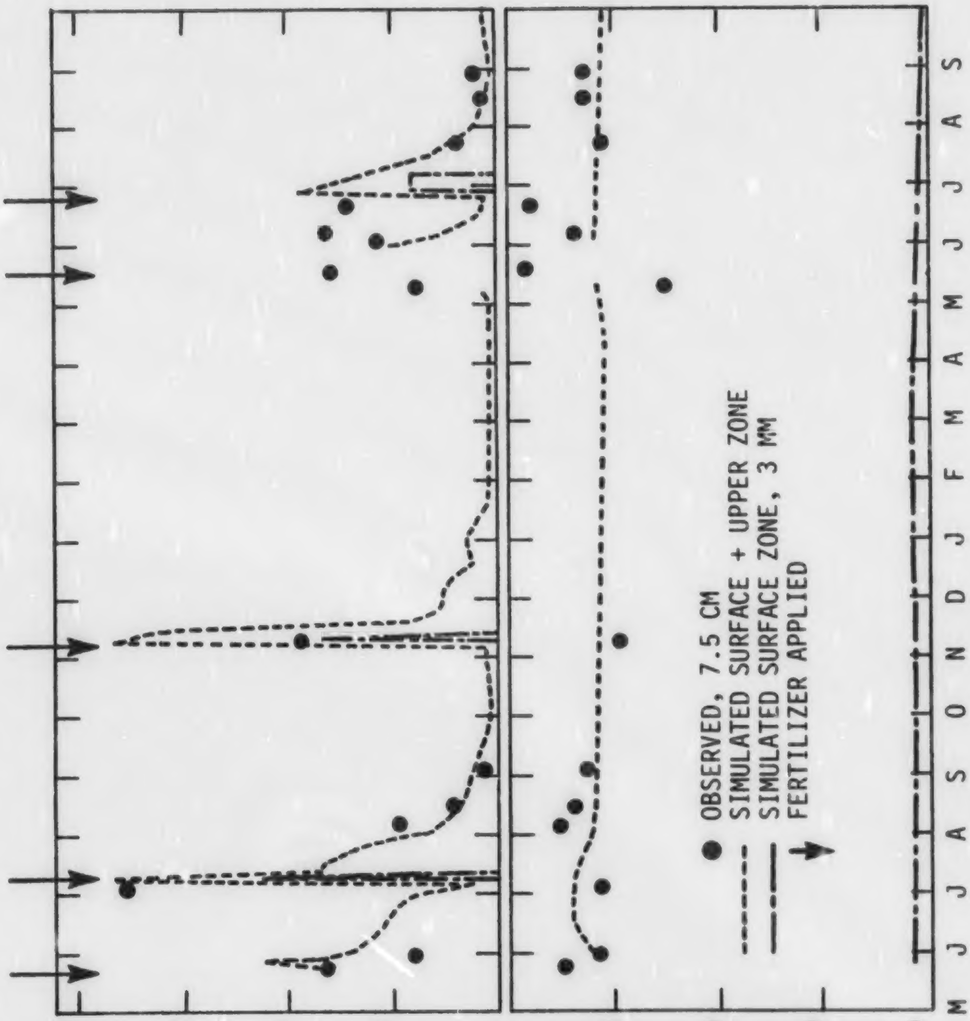


Figure 8.5 NO$_3$ and available P in surface and upper zone storage on the P6 watershed

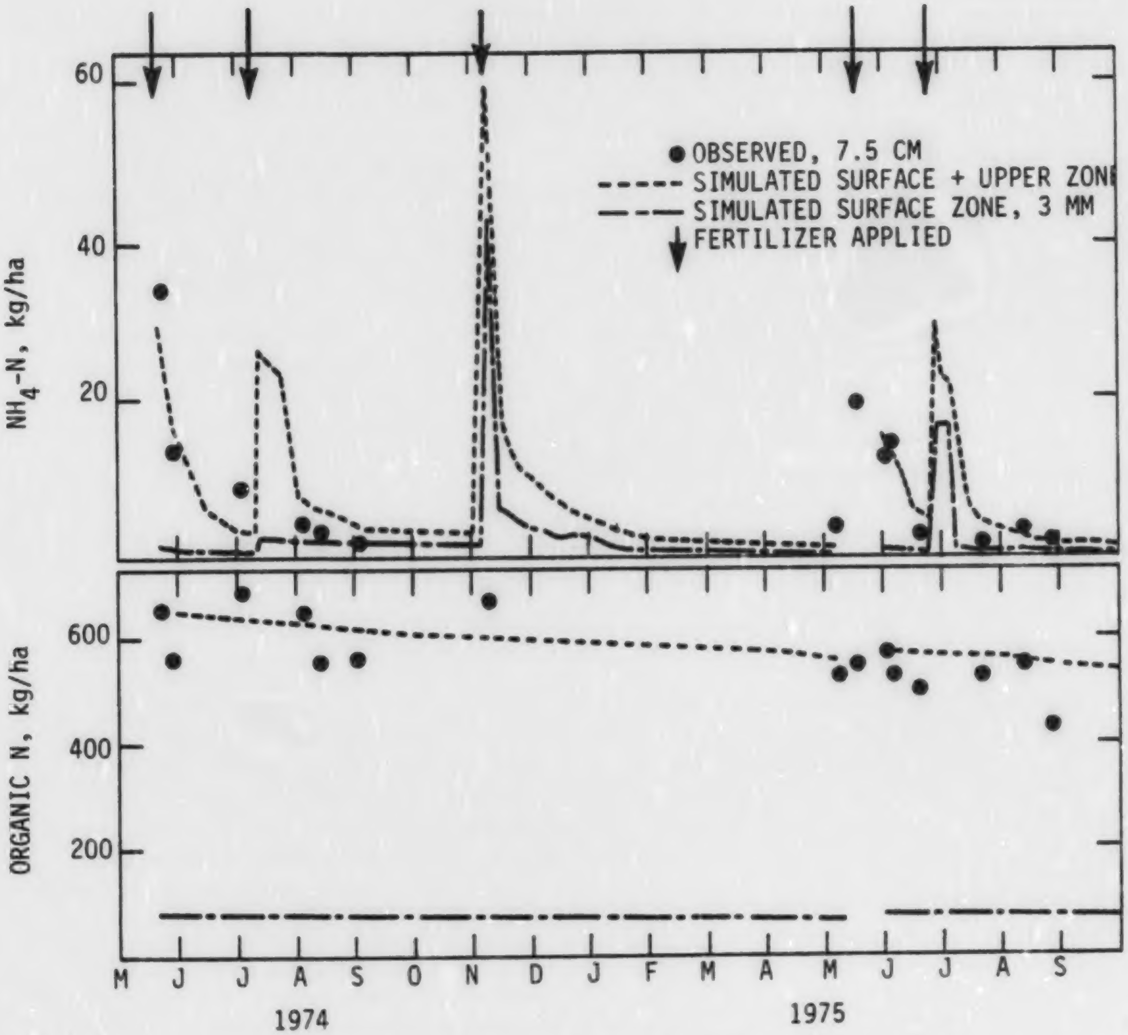


Figure 8.6 NH$_4$ and organic N in surface and upper zone storage on the P6 watershed

uptake simulation results are shown in Figure 8.7; no observed values were available. The planting dates are given in Table 5.2. In 1974, the P2 watershed crop uptake was limited by lack of moisture during the early growing season, so the 1974 uptake was simulated lower than 1975. The P6 watershed growing conditions were better than P2, so more nutrients were considered removed by the corn.

In general the simulation of the soil nutrient storages by the ARM Model is reasonably within the expected range of the observed values, especially since the observed values are an average that may vary 10-20 percent from the actual value. Hubbard (1975) calculated a standard deviation of 11.32 ppm about a mean of 113.95 ppm for 1974 Available P in the top 15 cm of the P6 watershed. Organic N and Organic P will vary even more. In addition, localized concentrations of fertilizer after application will increase the varibility of the samples. Therefore, considering the assumed variability of the observed values, the simulation results are good, with the exception of NO_3.

The P6 early July 1974 and June 1975 upper zone NO_3 simulation values are much lower than the observed values. Since the simulated NH_4 values are reasonable, the low NO_3 values are probably due to too little NH_4 being oxidized. Hubbard (1975) believed that the higher observed NO_3 values in the early July 1974 period are due to upward migration. The Cl concentration is also higher in the upper zone during that period. Since Cl does not undergo transformation, it is reasonable to assume both the NO_3 and Cl migrated upward during early July 1974 and June 1975. The ARM Model does not account for upward migration of pollutants so the simulation during these periods is lower. However, NO_3 in the runoff was over simulated during these periods, so an under simulation of the soil storage did not affect the simulation of nutrients in the runoff.

The poor NO_3 simulation in the fall and winter for both watersheds for each zone is partially caused by the poor temperature simulation. The regression equations that generate summer soil temperatures over simulate the fall and winter temperatures. The over simulation of these temperatures resulted in more mineralization and nitrification occurring during this period, resulting in the gradual increase of NO_3 in the lower zone (Figure 8.4). The over simulation of the lower zone values for the P2 watershed may also indicate the need for more percolation of nutrients to groundwater.

The surface zone simulated values show the effect of the rapid leaching of soluble nutrients from that zone. The rapid decline of the surface zone NO_3 and NH_4 for P6 (Figures 8.5 and 8.6) show this effect. Nearly complete removal of solutes from a surface layer 3.2 mm thick would be expected.

With the exception of when NO_3 was poorly simulated, the simulation of soil nutrient forms is good and satisfactory for our purposes. The simulation of both upper and lower zone NO_3 during the 1974 growing season for P2 (Figures 8.2 and 8.3) is good. It is not until late in the season that over simulation occurs. The simulation of TKN and Organic N for both watersheds (Figures 8.2, 8.3, and 8.6) is consistently within the range of observed values. In addition, the simulation of both Organic N and P (Figures 8.4

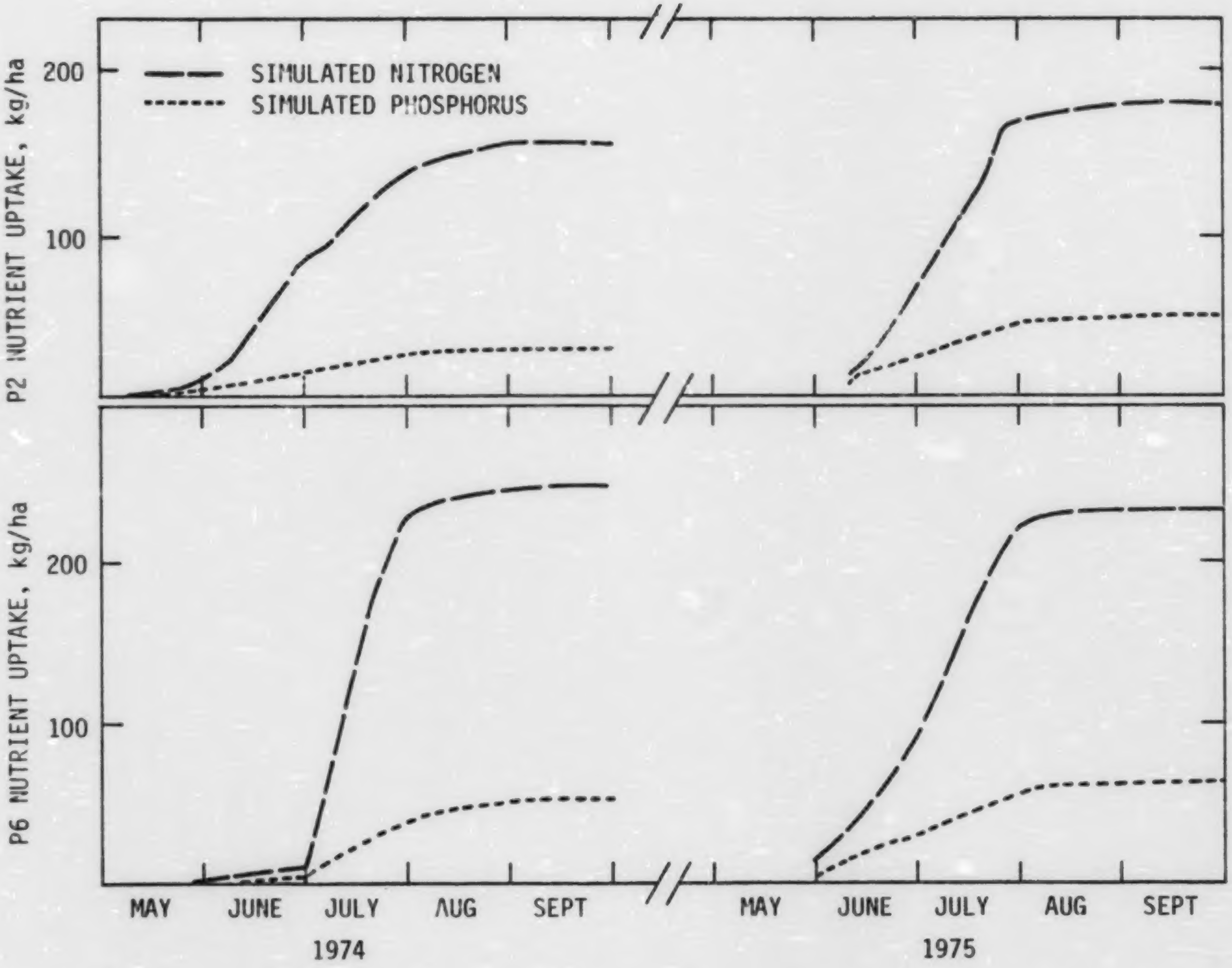


Figure 8.7 Simulated crop nutrient uptake from the P2 and P6 watersheds

and 8.6) is relatively stable as expected under actual field conditions. Likewise, Available P is within the range of observed values as well as being realistically stable. In summary, the first-order kinetic approach to soil nutrient storage simulation in the ARM Model is quite satisfactory.

The simulation of plant uptake storage also appears to be adequate. The monthly uptake factors and plant uptake reaction rates were versatile enough to produce the desired results. The crop uptake was calibrated based on observed crop growth and estimated total uptake. The distribution of the estimated total uptake was also based on the observed crop growth and was accomplished by using the monthly uptake factors.

MODEL IMPROVEMENTS AND FUTURE RESEARCH

As shown by the simulation results, the ARM nutrient model can satisfactorily represent the behavior of soil nutrient storages of most nutrient forms. Further testing of the current algorithms should be done before major changes are made. Sensitivity tests on the effect of reaction rate changes to soil storage changes under field conditions are needed. Likewise the effects of temperature changes on soil storages also need to be studied. More testing on different watershed soil and crop conditions is necessary to further evaluate the general applicability of the model. Testing and analysis of surface zone transformations and their impact on surface runoff and leaching processes is a major topic for future research. Changes should be made on the surface zone simulated behavior as indicated by future testing.

As further testing of the nutrient storage simulation is done, modifications may be needed to improve the model's applicability under varying field conditions. One of the first considerations should be to introduce the effect of moisture and oxygen content on the reaction rates. This would be needed if denitrification is significant. Also the effect of pH and carbon content may vary enough under some conditions to significantly influence reaction rates. Nitrogen fixation, ammonium uptake by plants, ammonium volatilization, and nutrients in precipitation could be introduced into the model. However, since these factors would further complicate application of the model, they should not be introduced until needed.

The simulation results and model development have uncovered specific areas where more field research is needed. For example, first-order reaction rate values applicable to field conditions are a major deficiency in the current literature. Also research is needed to develop more quantitative relationships between first-order reaction rates and various environmental factors (moisture, oxygen, pH). Most importantly, nitrogen and phosphorus uptake by different crops under field conditions needs to be described in a more quantitative manner. As this research is accomplished, the developed relationships could be incorporated into the ARM Model to allow more accurate and reliable modeling of soil nutrients.

SECTION 9

RUNOFF AND SEDIMENT SIMULATION RESULTS

The P2 and P6 watersheds were selected for simulation testing of the ARM Model because both pesticides and nutrients had been applied and then sampled in the runoff and the soil profile. Both are nonterraced watersheds and P6 is the larger of the Michigan watersheds. Also the data collected on these watersheds contained a minimum of inconsistencies and errors. This combination of requirements provided the best conditions in which to test all components of the ARM Model. Model testing for runoff and sediment loss was performed on the P2 watershed for the period of record, May 1973 through September 1975. The P6 watershed was simulated from May 1974 through September 1975. Data for the P6 watershed prior to May 1974 was questionable due to uncontrolled seepage under the outflow weir. This was corrected in April 1974.

Simulation of hydrology and sediment processes must be sufficiently accurate to allow evaluation of the pesticide and nutrient simulation results. Pesticides and nutrients are transported from the watershed either in solution in the runoff water or adsorbed onto eroded sediment paricles. Thus, pesticide and nutrient runoff results are dependent on the simulated runoff and sediment loss. Similarly, the simulated vertical movement of pesticides and nutrients in the soil profile depends on the model's representation of infiltration, percolation, and soil moisture processes.

Although the agreement between simulated and recorded runoff and sediment loss discussed below is generally good, discrepancies do exist. Some are a result of problems or errors in data collection and analysis. Such obvious errors must be considered when evaluating simulation results. Others are due to limitations of the hydrology and sediment algorithms of the model. Recommendations on how these limitations can be overcome and where additional research is necessary will be discussed at the end of this section.

P2 WATERSHED SIMULATION

A monthly volume comparison of simulated and recorded runoff on the P2 watershed (Figure 9.1) shows that the simulation of runoff is good for the important summer months. In the winter months (December through March) there is the tendency to over simulate runoff. This happens because of the new set of calibration parameter values used since the initial calibration of the Georgia watershed (the calibration parameter values can be found in Table 9.1). The major changes made were in the values of UZSN and INFIL. The input value of UZSN (upper zone nominal storage) was increased from 0.05

TABLE 9.1 INPUT FOR THE P2 AND P6 WATERSHEDS

Parameter	P2 Watershed Original	P2 Watershed Revised	P6 Watershed
Hydrology			
UZSN	0.05	0.50	0.20
LZSN	18.0	18.0	9.00
L	200.0	100.0	60.0
SS	0.025	0.025	0.06
NN	0.20	0.20	0.20
A	0.0	0.0	0.0
EPXM	0.12	0.12	0.12
PETMUL	1.0	1.0	1.0
K3			
January	0.30	0.30	0.20
February	0.30	0.30	0.20
March	0.30	0.30	0.20
April	0.40	0.40	0.20
May	0.40	0.40	0.30
June	0.50	0.50	0.30
July	0.70	0.70	0.50
August	0.80	0.80	0.45
September	0.60	0.60	0.40
October	0.50	0.50	0.30
November	0.40	0.40	0.20
December	0.30	0.30	0.20
INFIL	0.50	0.10	0.30
INTER	0.70	0.59	0.80
IRC	0.0	0.0	0.0
K24L	1.0	1.0	1.0
KK24	0.6	0.6	0.0
K24EL	0.0	0.0	0.0
KV	0.0	0.0	0.0
Snow			
RADCON			1.0
CCFAC			1.0
SCF			1.4
ELDIF			0.0
IDNS			0.14
F			0.0
DGM			0.0
WC			0.03
MPACK			1.0
EVAPSN			0.4
MELEV			892.0
TSNOW			32.0

(continued)

TABLE 9.1 (continued)

Parameter	P2 Watershed Original	P2 Watershed Revised	P6 Watershed
PETMIN			35.0
PETMAX			40.0
WMUL			1.0
RMUL			1.0
KUGI			0.0
Sediment			
COVPMO			
January	0.60	0.60	0.00
February	0.60	0.60	0.00
March	0.60	0.60	0.00
April	0.60	0.60	0.00
May	0.00	0.00	0.00
June	0.15	0.15	0.05
July	0.60	0.60	0.55
August	0.85	0.85	0.90
September	0.75	0.85	0.90
October	0.60	0.60	0.80
November	0.60	0.60	0.00
December	0.60	0.60	0.00
TIMTIL,YRTIL,SRERTL (max. of 12 events)			
	115,74,1.0	115,74,1.0	140,74,1.0
	114,75 2.0	114,75,2.0	136,75,0.8
JRER	1.90	1.90	2.2
KRER	0.08	0.08	0.15
JSER	1.30	1.70	1.40
KSER	0.25	0.50	0.50
SCMPAC	0.02	0.02	0.001
Initial Conditions			
Date	5/11/73	5/11/73	5/20/74
UZS	0.10	1.0	0.50
LZS	19.5	24.0	11.0
SGW	0.0	0.0	0.0
GWS	0.0	0.0	0.0
ICS	0.0	0.0	0.0
OFS	0.0	0.0	0.0
IFS	0.0	0.0	0.0
PACK			0.0
DEPTH			0.0
SRERI	2.0	2.0	1.0

to 0.50 while INFIL (the mean infiltration rate) was decreased from 0.50 to 0.10. These changes produced compensating effects and were necessary to achieve more reasonable soil moisture storage values for simulating vertical transport of solutes. By changing these parameters more runoff was simulated during the winter months. By lowering the value of INFIL less water could infiltrate and thus more was available for runoff. The long duration, low intensity winter storms allowed the lower INFIL value to have a pronounced effect. However, the summer runoff was not substantially changed due to the high intensity, short duration summer thunderstorms and the higher upper zone moisture storage maintained by the higher UZSN.

Actually, the revised parameters (higher UZSN, lower INFIL) do not as accurately represent the summer thunderstorms as the original parameters because of the lesser effect of INFIL on these short duration intense storms. Moreover, it is questionable whether infiltration and subsurface characteristics can be accurately calibrated on these small watersheds. Bruce, et al. (1976) have concluded that the surface soil horizon (0-18 cm) basically determines the infiltration and resulting runoff characteristics for a major portion of a runoff event on these small Georgia watersheds. Subsurface characteristics do not effect infiltration until 30-40 minutes into an event. Consequently, the simulated impact of the summer thunderstorms is more dependent on UZSN than INFIL. The revised parameter values are a compromise between runoff and soil moisture simulation. They adequately represent the runoff for the summer months and give more reasonable soil moisture storages values. For these reasons the new set of values was selected over the old.

This conflict between hydrology parameter values best suited for surface runoff and those best for soil moisture storages has not been completely resolved. The LANDS section of the ARM Model was not originally designed to accurately simulate detailed soil moisture movement. Nor is a simple solution available. A detailed discussion of this problem is in Section 6.

Although the P2 watershed monthly simulated and recorded sediment loss (Figure 9.1) compare reasonably well, problems do exist. The 1974 recorded sediment loss is lower than the other years. In 1974 tillage and planting occurred in late April and the first major sediment producing event occurred about 60 days later. In 1973 and 1975, tillage and planting was in mid-May with the first major event about 15-20 days later. Thus, the extra lag time and intervening changes on the watershed in 1974 appears to be the major factor for the lower sediment loss.

Sediment loss as represented in the model, results from rainfall detachment of soil particles and transport of these particles or fines to the stream by surface runoff. In addition, production of soil fines by tillage operations significantly contributes to the total fines available for transport. As shown in Figure 9.1, the major sediment loss occurs within 2 to 3 months following tillage operations. Changes in crop canopy and settling and compaction of the soil surface are the major processes occurring in this intervening period that determine the sediment-producing impact of the first event following tillage. The ARM Model accepts 12 monthly crop cover values

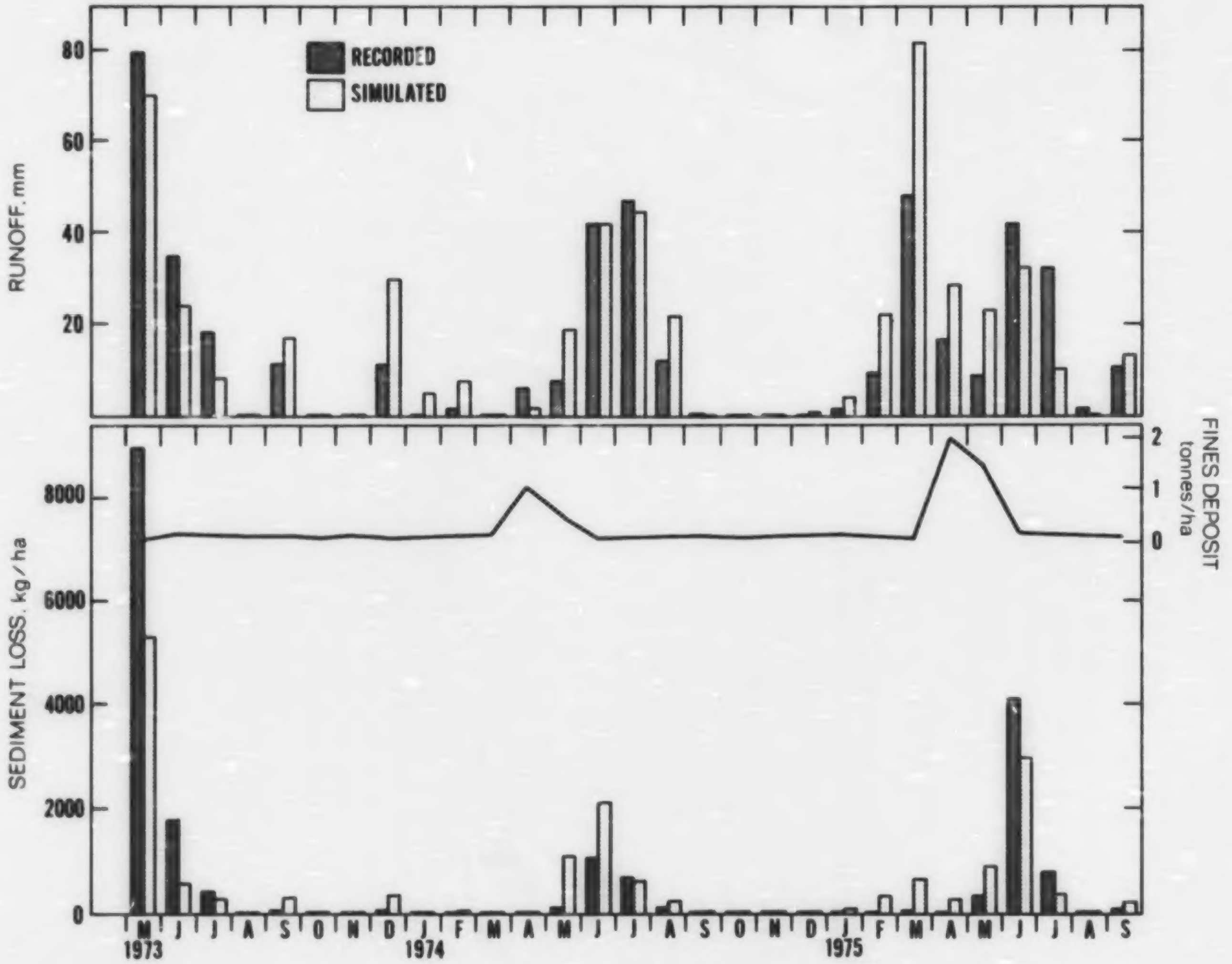


Figure 9.1 Monthly runoff and sediment loss from the P2 watershed

for the first day of each month; crop cover on any day is determined by linear interpolation. Thus for multi-year simulation runs the crop cover is the same for corresponding days in each year of the simulation. For the P2 watershed, the average cover calculated by this procedure underestimates the crop cover in 1974 and overestimates the cover in 1973 and 1975. This effect contributes to the differences in Figure 9.1. Separate calibration runs with different cover values for each year would improve the agreement between the simulated and recorded sediment loss.

To account for the settling and compaction of the soil surface following tillage, a new parameter SCMPAC has been added to the ARM Model to decrease on each nonrain day the amount of fines available for transport. SCMPAC is essentially a first-order decay parameter that reduces the soil fines storage in the following manner:

$$\mathrm{SRER(T)} = \mathrm{SRER(T-1)} * (1.0 - \mathrm{SCMPAC}) \qquad (9.1)$$

where SRER(T) = soil fines storage on day T, tonnes/ha
SRER(T-1) = soil fines storage on day T-1, tonnes/ha
SCMPAC = soil compaction factor, day^{-1}

On the watershed the decrease in soil fines is due to natural settling and aggregation of particles, and compaction by rainfall and agricultural operations. These processes are complex functions of soil characteristics, meteorologic conditions and agricultural practices. The use of the SCMPAC parameter is a simple approximation of the overall impact of the above processes within the scope of this project. Future research should consider more detailed methods of representation.

A SCMPAC value of 0.02 for the P2 watershd helped to reduce the fines storage and resulting sediment loss in 1974. Even with this compaction rate the simulated sediment loss in 1974 was substantially greater than recorded. Within the limitations of the sediment model, the only remaining option was to assume that tillage operations in 1974 produced less fines than in 1973 and 1975. Thus, the sediment simulation results in Figure 9.1 are based on 2.24 tonnes/ha of fines produced by tillage in 1974 and 4.48 tonnes/ha in 1973 and 1975. This further points out the need to investigate the impact of tillage on sediment fines production.

With the above adjustments, the individual hydrographs and sediment graphs for the P2 watershed show good agreement between simulated and recorded results for the major storms during the summers of all three years (Figure 9.2-9.4). Other storm event graphs for the P2 watershed can be found in Appendix B. However, the effect of tillage in dampening the peak of the recorded hydrograph and retarding the overland flow is noticable in the storms of May 24, 1974 and June 11, 1975 (Figure 9.3 and 9.4, respectively). The hydrologic algorithms included in the ARM Model do not handle this man-made phenomenon. Thus, over simulation of early season storms is to be expected. Storms occurring later in the crop season when the soil has become compacted do not exhibit this problem. In general, an accurate runoff simulation will produce reasonable sediment simulation results on the P2 watershed. Tillage and other man-related activities (terracing, contour,

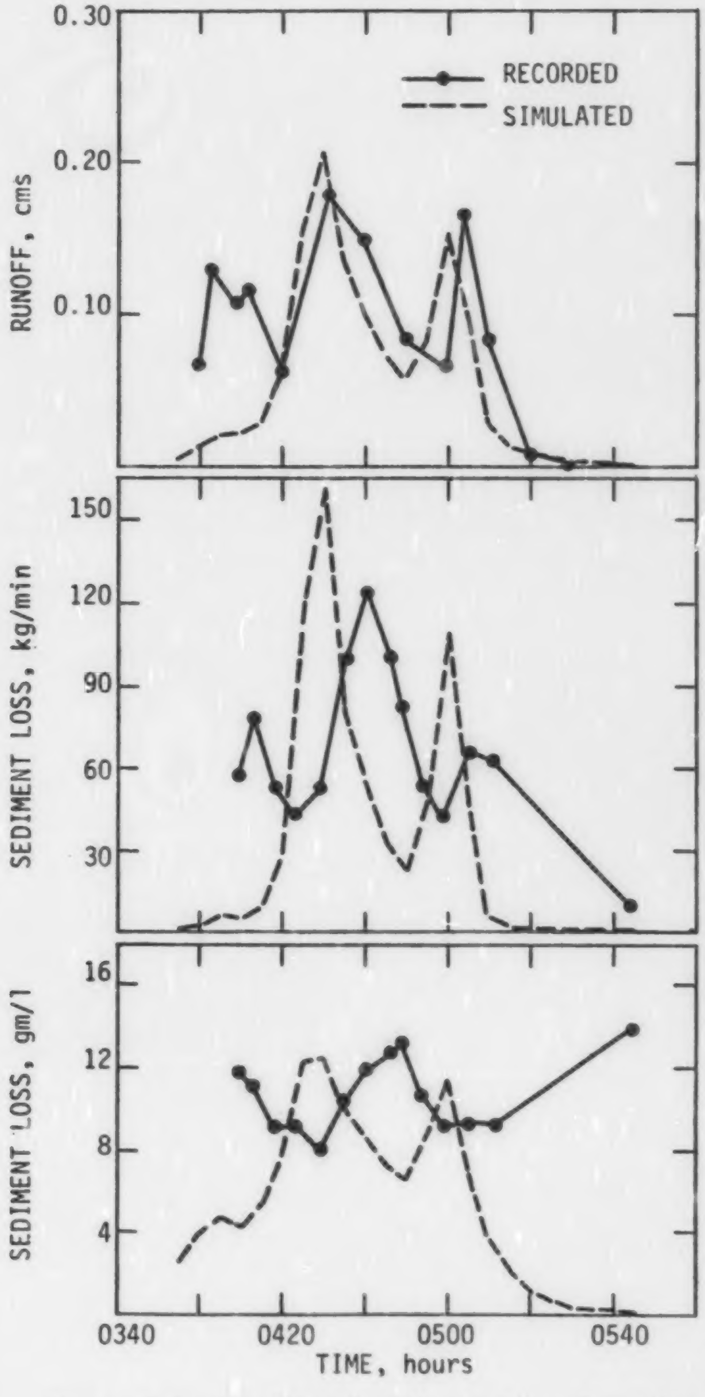


Figure 9.2 Runoff and sediment loss from the P2 watershed for the storm of May 28, 1973

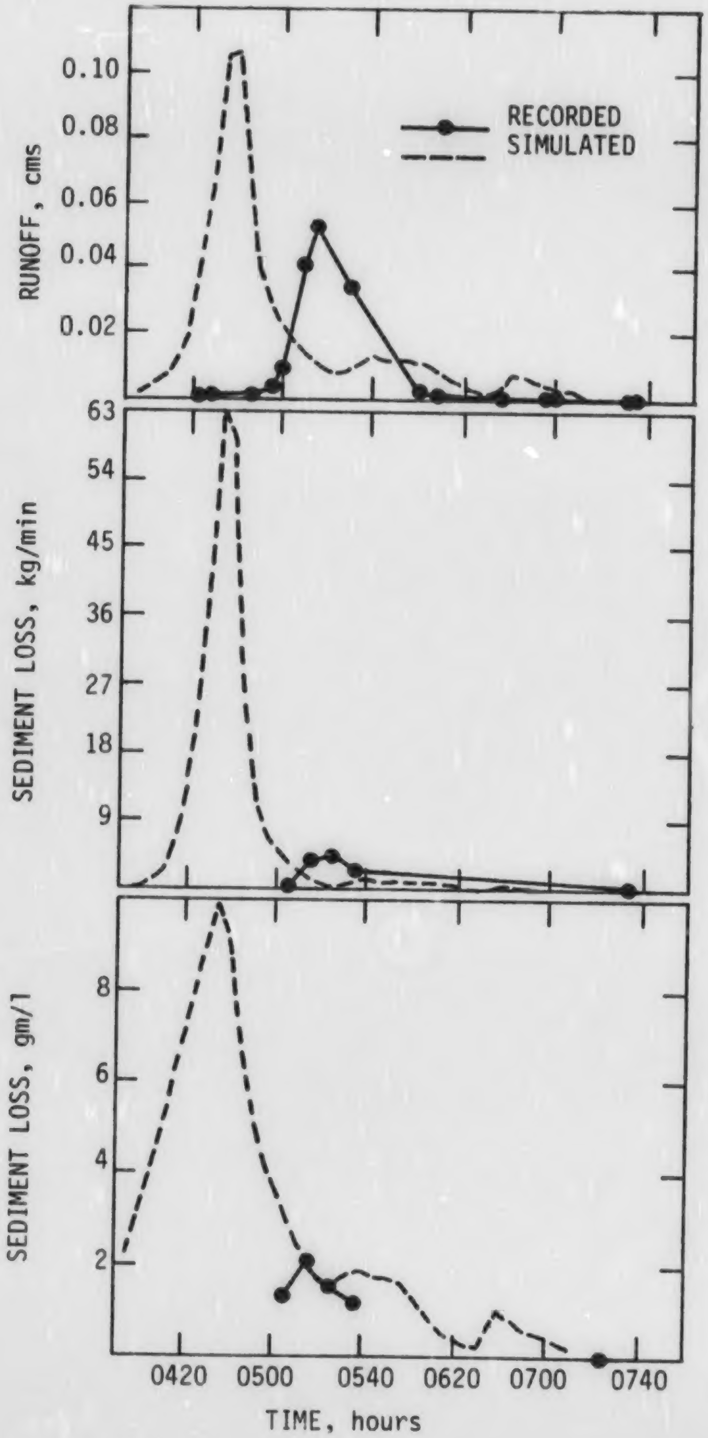


Figure 9.3 Runoff and sediment loss from the P2 watershed for the storm of May 24, 1974

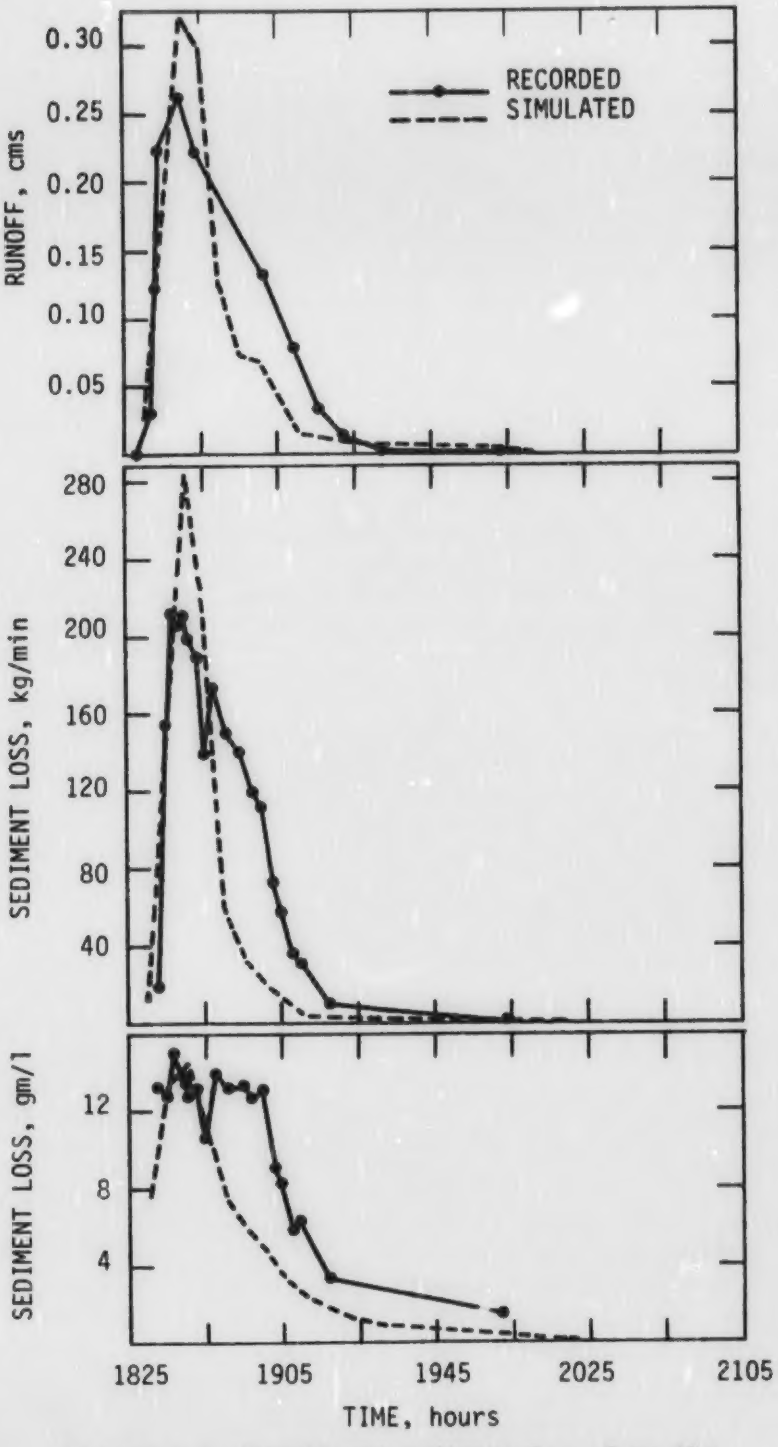


Figure 9.4 Runoff and sediment loss from the P2 watershed for the storm of June 11, 1975

planting, grass waterways, etc.) disturb the hydrologic characteristics of a watershed as stated above. Further research is needed to fully understand how these management practices affect runoff and how their influence can be incorporated into the LANDS segment of th ARM Model.

P6 WATERSHED SIMULATION

Like the P2 watershed, the monthly runoff and sediment loss simulation for the P6 watershed is generally quite good (Figures 9.5). However, problems with the simulation of snowmelt and runoff during the months of February and March 1975 are evident. These problems, which result in an under simulation of runoff during these months, are attributed to difficulties in properly simulating snowmelt. During winter periods frozen ground conditions severely decrease infiltration rates resulting in greater runoff than would otherwise occur. Also, temperature gradients in the soil profile can result in upward movement of moisture that would be available for runoff during the thaw periods.

Although the ARM Model snowmelt routine decreases infiltration for freezing conditions, the complex frozen ground processes that determine the resulting snowmelt and runoff are not adequately represented. Thus, the simulated runoff is considerably less than recorded for February and March 1975. Research is needed to better understand how this phenomenon of frozen ground can best be simulated.

Except for April 1975, monthly sediment loss on the P6 watershed compared well between the simulated and recorded results, as shown in Figure 9.5. The April discrepancy is due entirely to simulation of the April 18 storm (Figure 9.6). Runoff during this storm is simulated quite well while sediment is grossly under simulated. The low sediment concentrations for this storm are due to more sediment fines on the watershed available for transport than was simulated by the sediment algorithms. Freeze-thaw cycles during the winter could have produced fines which were washed from the watershed during this first major spring storm. Also, detachment or scour by runoff, which is not presently simulated, likely contributed to the high recorded sediment concentrations especially with the saturated surface soil conditions existing on the watershed. Detachment by runoff is a significant mechanism to some degree on most watersheds. Its incorporation and simulation in the ARM Model would allow better representation of the highly variable nature of erosion, and should be the next major improvement to the sediment algorithms.

Except for the April 1975 storm the simulated and recorded runoff and sediment loss (Figures 9.6 and 9.7 and Appendix C) for individual storm events is generally quite good. However, some events (not included) exhibit a problem with the areal variation in rainfall. The two adjoining watersheds, P6 and P7, are a good example of how areal rainfall variation can make simulation difficult. One raingage was used for both watersheds. Runoff from each watershed was measured separately. The runoff record from P7 is different from the neighboring P6 watershed. The model assumes that the recorded rainfall falls uniformly over the entire area, and produces runoff in response to this uniform rainfall. But in fact thunderstorm

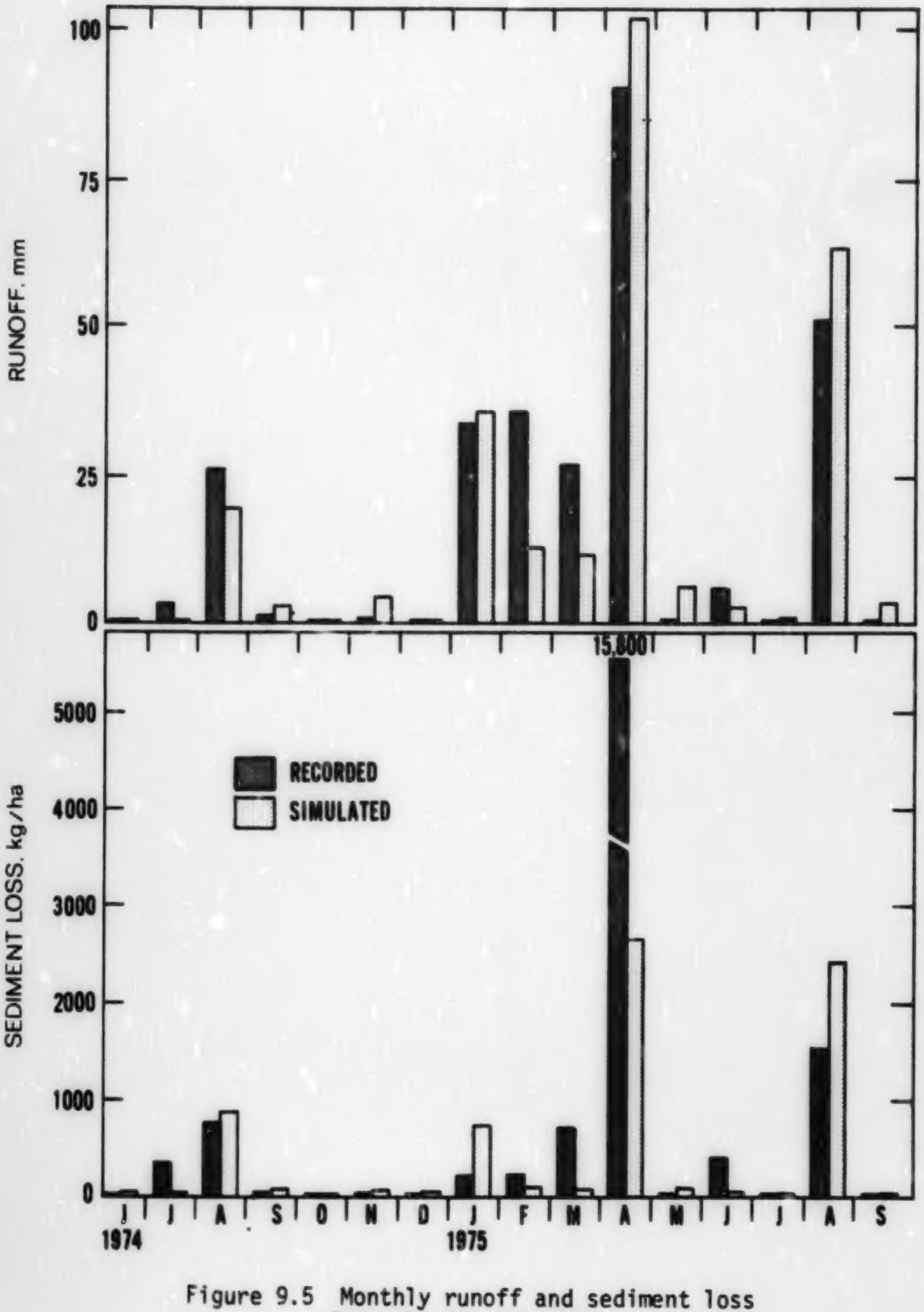


Figure 9.5 Monthly runoff and sediment loss from the P6 watershed

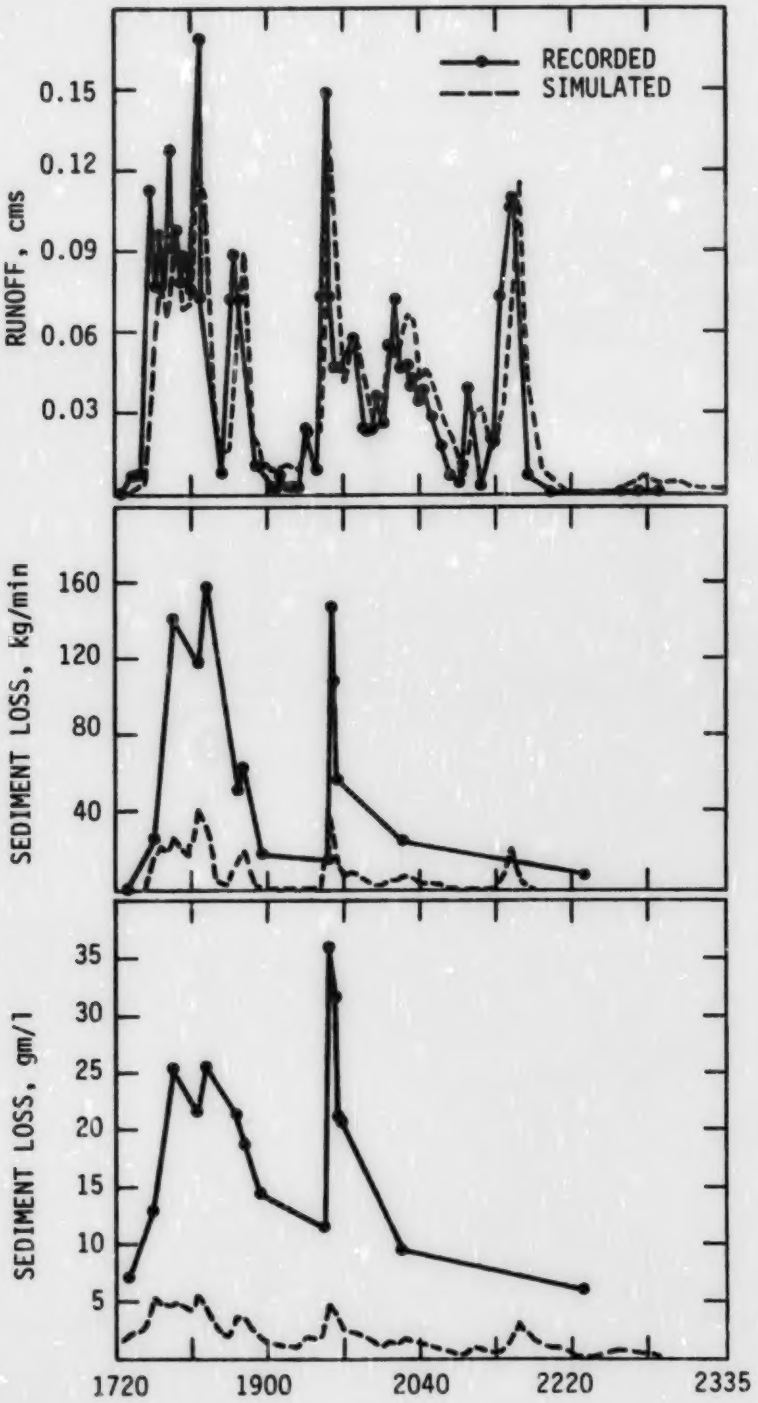


Figure 9.6 Runoff and sediment loss from the P6 watershed for the storm of April 18, 1975

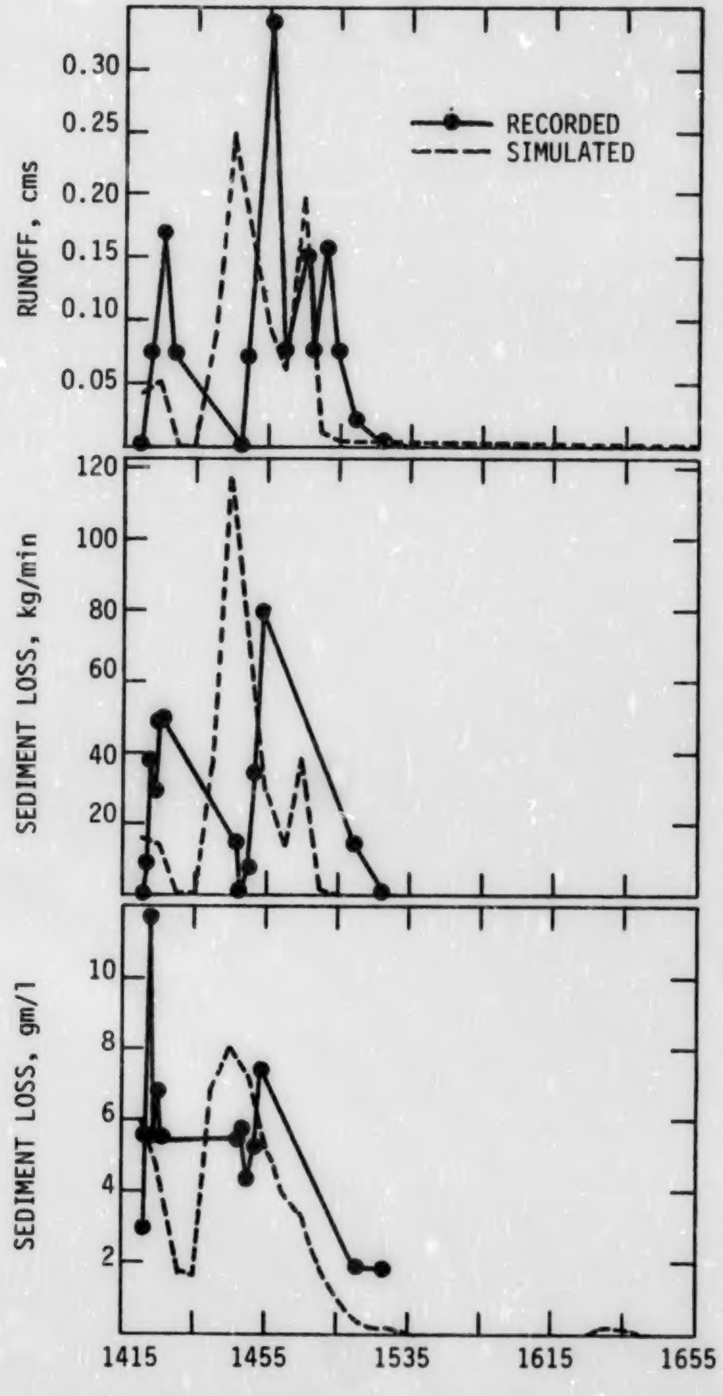


Figure 9.7 Runoff and sediment loss from the P6 watershed for the storm of August 20, 1975

rainfall, typically seen in the summer at the watershed sites, is not uniform but intense and localized. Consequently, the accuracy of the simulation decreases as the amount of areal variability of the rainfall increases. An understanding of this potential problem is vital in reviewing the runoff and sediment loss results of the P6 watershed.

A discussion of the runoff and sediment loss simulation is not complete without mention of mass removal and concentration graphs when viewing sediment loss results. Concentration (measured in mg/l) fluctuates according to the amount of runoff water available. It is an indication of the importance of the possible pollutant (in this case sediment) in the waterway and directly influences the quality of the receiving waters. This type of measurement is important in streams containing water year-round, as the organisms in the streams are sensitive to changes in concentrations of pollutants and particularly toxic substances. However, the streams in the P2 and P6 watersheds exist only during storm events. They receive no groundwater and therefore are simply dry waterways when surface runoff and interflow are not occurring. In cases like these, mass removal (kg/minute) is a better indicator of the effects of watershed management and the pollutant loss expected from different events and practices. Mass removal also shows a direct connection between the pollutant loss and its transport mechanism, runoff. Thus, it is a good indication of the ability to simulate the combined runoff-sediment loss process.

SUMMARY

A review of the simulation results of runoff and sediment loss on the P2 and P6 watersheds shows that they are reasonable and can be used to evaluate pesticide and nutrient runoff simulation. Problems that are present in the results have been isolated and discussed. Some (e.g., areal variability of rainfall) cannot be corrected without major additions to the ARM Model and the data collection procedures. Other problems can be solved with further research and development of simulation methods. Detachment of soil fines by runoff can and should be included in the model. The development of such algorithms should be a major priority in future research. Simulation of all the erosion processes by particle size should be investigated to evaluate the potential benefits for the simulation of sediment, pesticide, and nutrient transport as a function of particle size. Such work would be especially beneficial to coupling the ARM Model to a stream transport model to simulate sediment and attached pollutant movement throughout a watershed.

Research is also necessary for a more complete modeling of the effects of agricultural management practices on both runoff and sediment loss. Parameter changes that reflect different agricultural activities need to be quantified. In addition, parameters that are directly affected by these activites may need monthly or seasonal values. This has been done for crop cover (COVPMO) and index to actual evaporation (K3) in the current version of the model. Investigation of seasonal variations for nominal upper zone storage (UZSN) and infiltration (INFIL) should be undertaken.

SECTION 10

PESTICIDE RUNOFF SIMULATION RESULTS

The pesticides paraquat (1,1'-dimethyl -4,4-bipyridinium ion) and atrazine (2 - chloro-4-ethylamino-6-isopropylamino-s-triazine) were applied to both the P2 and P6 watersheds during the 1973-1975 growing seasons. These pesticides have been simulated by the ARM Model and the amount of pesticide runoff compared with recorded data. This section discusses the pesticide simulation results and the problems encountered along with conclusions and recommendations related to pesticide simulation.

Paraquat is a highly ionic herbicide that rapidly and irreversibly adsorbs onto sediment particles. Thus, the amount of paraquat washed off a watershed is directly related to the amount of sediment eroded. By comparison, atrazine both dissolves in water (35 ppm) and adsorbs on sediment. Thus, the study of atrazine allows the comparison of the single-valued (SV) and nonsingle-valued (NSV) adsorption/desorption pesticide functions. Evaluation of these functions is important as the majority of pesticides are transported by both runoff and sediment. The division between the water and sediment phase is critical to the evaluation of the potential pollutional impact of different pesticides. Highly soluble pesticides will infiltrate deeper into the soil profile than less soluble ones. Soluble pesticides will be affected by practices reducing runoff while soil erosion control will limit the wash off of pesticides transported on sediment particles. Thus, determining the ability of the SV and NSV algorithms to correctly divide a pesticide between its adsorbed and solution phase coupled with an accurate degradation approach is essential to a good simulation of pesticide runoff.

MONTHLY SIMULATION RESULTS

The comparison of monthly simulated and recorded runoff amounts of paraquat on the P2 watershed (Figure 10.1 and Table 10.1) is good. Paraquat, as noted above, is not found in solution and, therefore, is dependent on eroded sediment as its transport mechanism. Paraquat simulation is high compared to the recorded data in May and June, 1974. A review of the P2 sediment loss simulation will show that these months are over simulated for sediment loss. Thus, a better simulation of sediment removed on the P2 watershed will result in closer agreement between simulated and recorded paraquat removal for this period.

The P2 atrazine results also show a good comparison between simulated and recorded monthly runoff values (Figure 10.1 and Table 10.1). Figure 10.1 also shows the results of using both the SV and NSV algorithms for atrazine

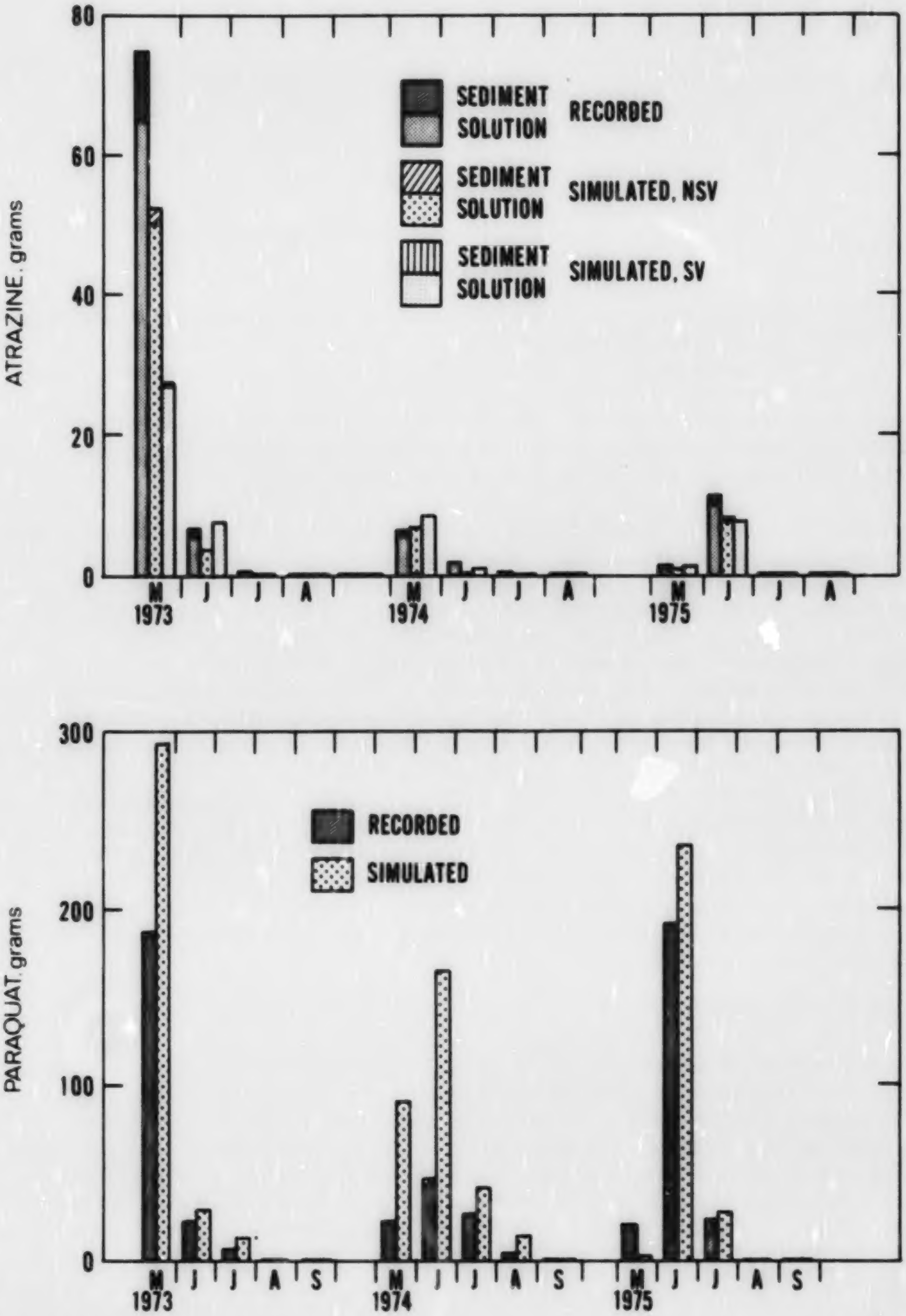


Figure 10.1 Monthly pesticide removal from the P2 watershed

TABLE 10.1 PESTICIDE RUNOFF SIMULATION RESULTS FOR THE P2 WATERSHED

		Atrazine						Paraquat	
		Recorded		NSV Simulation		SV Simulation		Recorded	Simulated
		(sed)	(sol)	(sed)	(sol)	(sed)	(sol)	(sed)	(sed)
1973	May	10	65	2	50	1	27	188	294
	Jun	1	5	0	4	0	8	23	29
	Jul	0	1	0	0	0	0	7	14
	Aug	0	0	0	0	0	0	0	0
	Sep	0	0	0	0	0	0	0	13
	Total	11	71	2	54	1	35	218	350
1974	May	1	6	0	7	0	9	23	91
	Jun	0	1	0	0	0	1	47	164
	Jul	0	0	0	0	0	0	27	42
	Aug	0	0	0	0	0	0	5	15
	Sep	0	0	0	0	0	0	0	0
	Total	1	7	0	7	0	10	102	312
1975	May	1	1	0	1	0	1	20	34
	Jun	1	10	1	8	0	8	191	237
	Jul	0	0	0	0	0	0	25	27
	Aug	0	0	0	0	0	0	5	15
	Sep	0	0	0	0	0	0	0	0
	Total	2	11	1	9	0	9	236	312

notes: NSV - nonsingle-valued adsorption/desorption
SV - single-valued adsorption/desorption simulation
sol - solution form
sed - sediment adsorbed form

simulation. In addition, a breakdown is given for the recorded atrazine transported in solution and on sediment. Atrazine runoff results for SV and NSV algorthms differ little except in the first summer: May and June of 1973. However, looking at all three summers when atrazine was applied on the P2 watershed the NSV results generally look better than the SV results in terms of removal in solution, which is the major removal mechanism. Little atrazine is removed on sediment (less than .15 percent of the total amount of atrazine removed). For the comparison of NSV and SV's ability to simulate atrazine removal on sediment, the NSV results produce more removal, although less than recorded. But because of the small amounts of atrazine measured as removed from the P2 watershed it cannot be said that the results are conclusive. Also, problems arise from the variability in determining the value for K in the Freundlich adsorption/desorption algorithm. Because of the lack of laboratory data evaluating the Freundlich constants for the watershed soils exact values have not been determined. Moreover laboratory determinations will often produce a range of values. This variability in K hinders evaluation of the relative merits of using either the SV or NSV algorithm.

A further complication, but one which tends to support the concept of NSV adsorption/desorption, is the relative change in partitioning of runoff atrazine between the adsorbed and solution forms during the growing season. Recorded data has shown the pesticide's tendency to adsorb onto sediment particles increases with time after application. NSV adsorption/desorption will produce the same phenomenon, but it is not clear that this is the mechanism responsible for these observations in the field data. More laboratory research into this question is necessary to verify this observation and the physical and chemical reasons behind it.

The simulation of paraquat and atrazine on the P6 watershed (Figure 10.2 and Table 10.2) was not as good as the P2 pesticide simulation. Paraquat runoff results are acceptable, except for the month of August, 1975. Sediment removal for this month is high; paraquat removal is higher. However, it is difficult to determine where the problem lies. Review of paraquat data collected from soil core samples and discussion with EPA personnel familiar with the sampling program on the P6 watershed indicate that the recorded data must be viewed with caution. Uncertainty in the accuracy of this data makes evaluation of the pesticide results difficult.

The monthly atrazine runoff results on the P6 watershed show even less resemblance between the simulated and recorded values than was the case for paraquat. The accuracy of the recorded data can be questioned, but other problems are also evident. Runoff is over simulated in May 1974 due to the hydrologic impact of plowing and planting operations not being represented in the model. The storm on May 29, 1974 occurred eight days after application and removed all of the atrazine for the month of May. For this storm there was a large amount of atrazine available for runoff in the surface zone and it was simulated as running off in solution during this storm. Atrazine was again applied in November, 1974. This application was followed by cold weather and snow. The lowered temperatures decreased the rate of biological degradation (although there is no soil core data to confirm this hypothesis) and more atrazine was then available for runoff

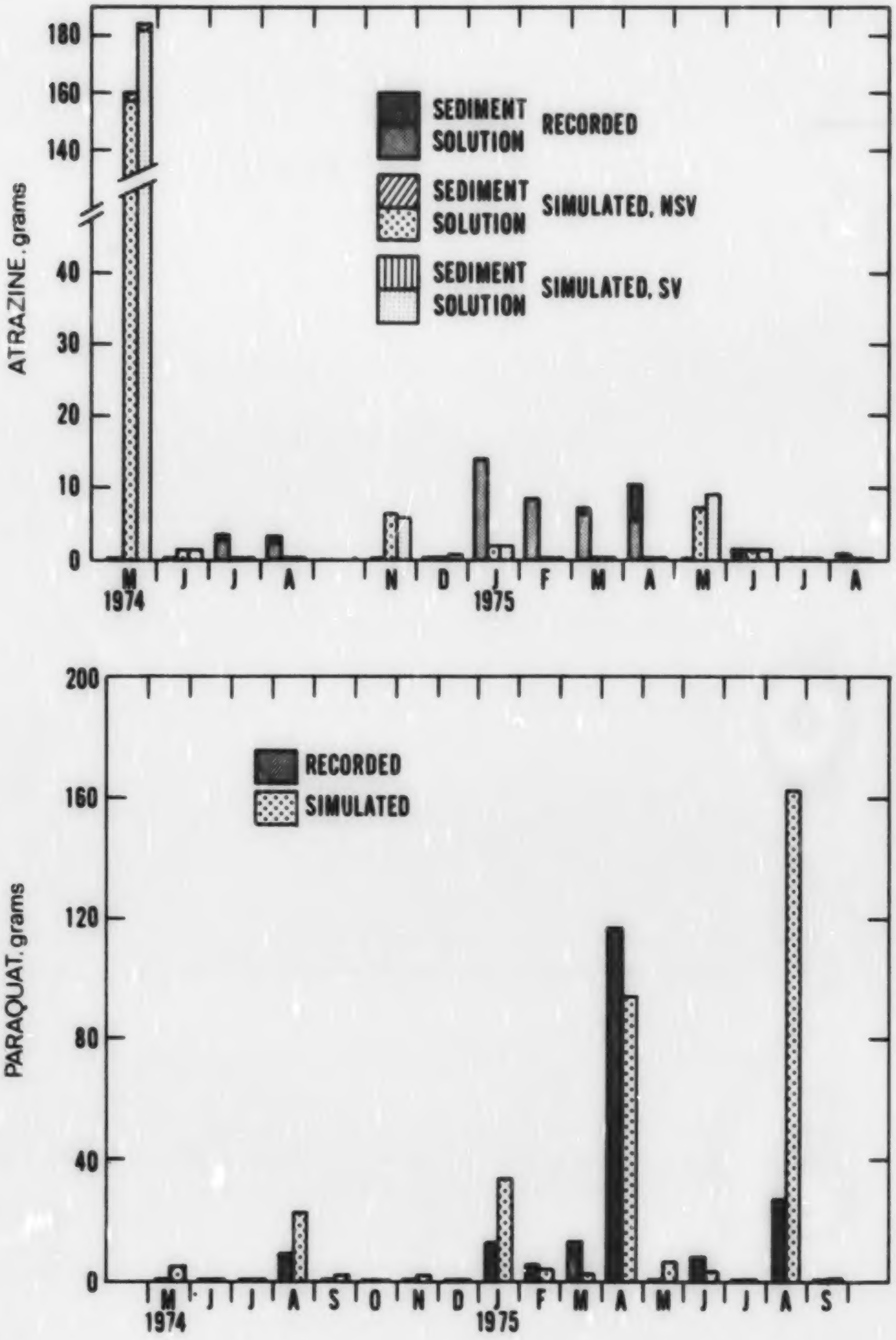


Figure 10.2 Monthly pesticide removal from the P6 watershed

TABLE 10.2 PESTICIDE RUNOFF SIMULATION FOR THE P6 WATERSHED

		Atrazine						Paraquat	
		Recorded		NSV Simulation		SV Simulation		Recorded	Simulated
		(sed)	(sol)	(sed)	(sol)	(sed)	(sol)	(sed)	(sed)
1974	May	0	0	3	137	3	152	0	5
	Jun	0	0	0	1	0	1	0	0
	Jul	1	3	0	1	0	1	0	0
	Aug	2	1	0	0	0	0	9	23
	Sep	0	0	0	0	0	0	0	2
	Oct	0	0	0	0	0	0	0	0
	Nov	0	0	0	0	0	0	0	2
	Dec	0	0	0	0	0	0	0	0
	Total	3	4	3	139	3	154	9	32
1975	Jan	0	14	0	2	0	2	12	34
	Feb	0	9	0	0	0	0	6	4
	Mar	1	6	0	0	0	0	13	3
	Apr	5	5	0	0	0	0	117	94
	May	0	0	0	0	0	0	0	6
	Jun	0	1	0	1	0	1	8	4
	Jul	0	0	0	0	0	0	0	0
	Aug	0	1	0	0	0	0	27	163
	Sep	0	0	0	0	0	0	0	1
		6	36	0	3	0	3	183	309

notes: NSV - nonsingle-valued adsorption/desorption
SV - single-valued adsorption/desorption simulation
Sol - solution form
Sed - sediment adsorbed form

during warm melt periods later in January, February, March, and April of 1975 than simulated. A biologically oriented degradation approach which uses soil temperatures would be better able to handle this problem of pesticide winter application and degradation.

STORM EVENT SIMULATION

An analysis of individual pesticide runoff events on the P2 watershed soon after application shows that they match recorded results very well (Figures 10.3-10.5). The paraquat simulation (Figure 10.3) matches the sediment simulation for the storm of May 28, 1973, as one would expect. Atrazine removal by sediment for this event is low (Figure 10.4), but still within the range of accuracy required. But even with the use of NSV adsorption/desorption the amount of atrazine removed is not as great as was recorded. Simulation of atrazine removed in solution is excellent however.

It can be seen at later events after application (Figures 10.6) that the simulated amount of atrazine is not as great as that recorded. The reason for the small amount of atrazine runoff is that only a relatively small amount is available for runoff. Atrazine (and other soluble pesticides) can be removed from the watershed by transport on sediment particles eroded from the surface zone, runoff in overland flow interacting with the surface layer, and runoff in interflow coming from the upper zone. Interflow contributes less than overland flow/surface runoff in transporting atrazine from the watershed. For the P2 watershed interflow contributes from 21 percent (NSV adsorption/desorption) to 48 percent (SV) of the total atrazine removed. This compares to 74 percent (NSV) to 51 percent (SV) for atrazine removed by surface runoff. This fact, combined with knowledge that the ARM Model permits soluble pesticides to percolate faster from the surface zone to the upper zone than is actually observed (Figure 10.7), results in an understanding of why the simulation of atrazine runoff decreases in accuracy with time since application. Retardation of soluble pesticide movement from the surface to upper zone (perhaps in the same manner as is done for solute leaching from the upper to lower zone) would keep more pesticide available on the surface for runoff and sediment transport.

Additional pesticide runoff simulation results for paraquat and atrazine for the P2 watershed will be found in Appendix B. Appendix C contains individual paraquat and atrazine runoff results for the P6 watershed. Tables 10.3 and 10.4 provide the pesticide parameter values and the amount of pesticides applied on the two watersheds.

SUMMARY

A review of the pesticide runoff simulation results show that while in general the results are good, problems still exist. Solution pesticides show greater variability than the adsorbed forms and are not simulated as accurately with the ARM Model. A better understanding of the movement and interactions of soluble pesticides in the upper layers of the soil is needed to better simulate their transport by surface runoff and interflow.

Pesticides attached to sediment are relatively stable and are simulated

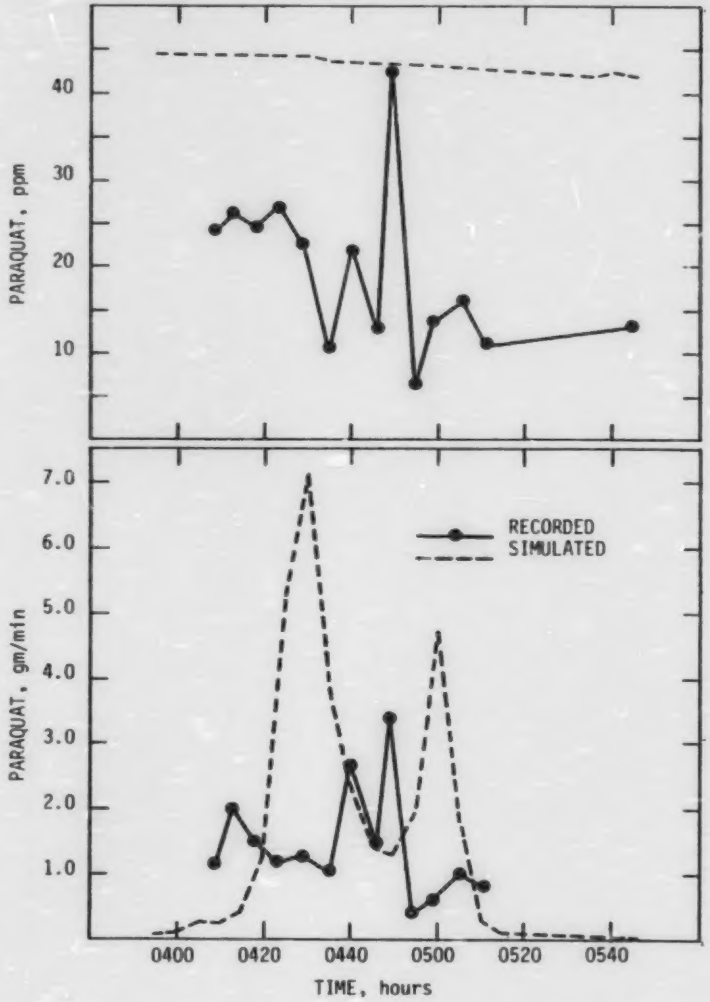


Figure 10.3 Paraquat removal from the P2 watershed for the storm of May 28, 1973

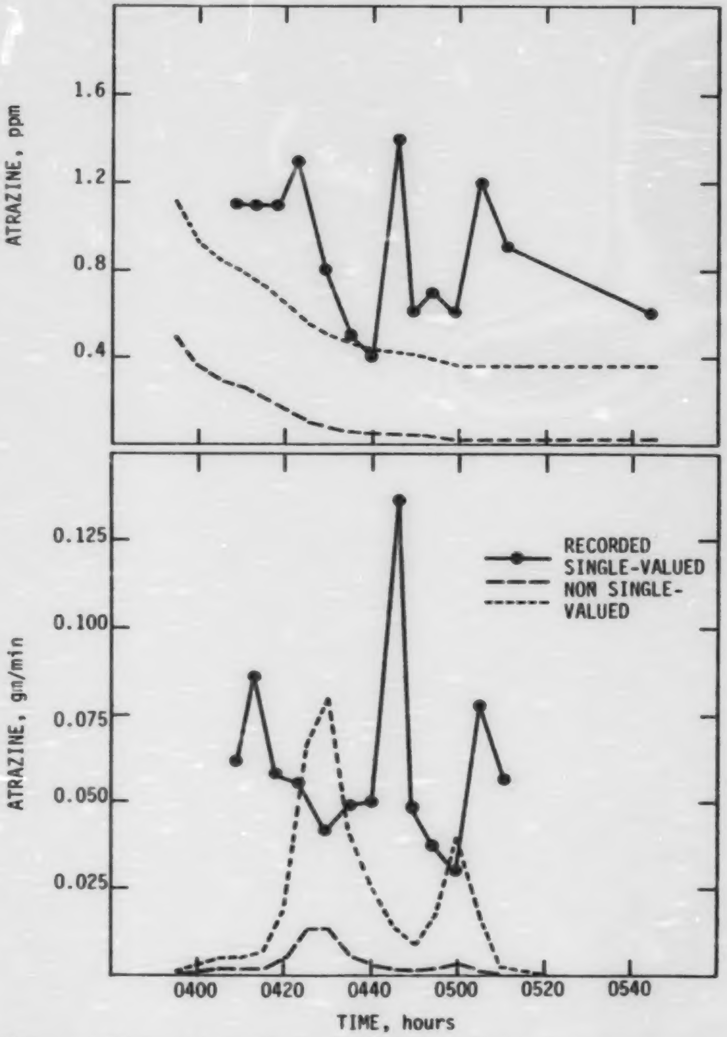


Figure 10.4 Atrazine removal on sediment from the P2 watershed for the storm of May 28, 1973

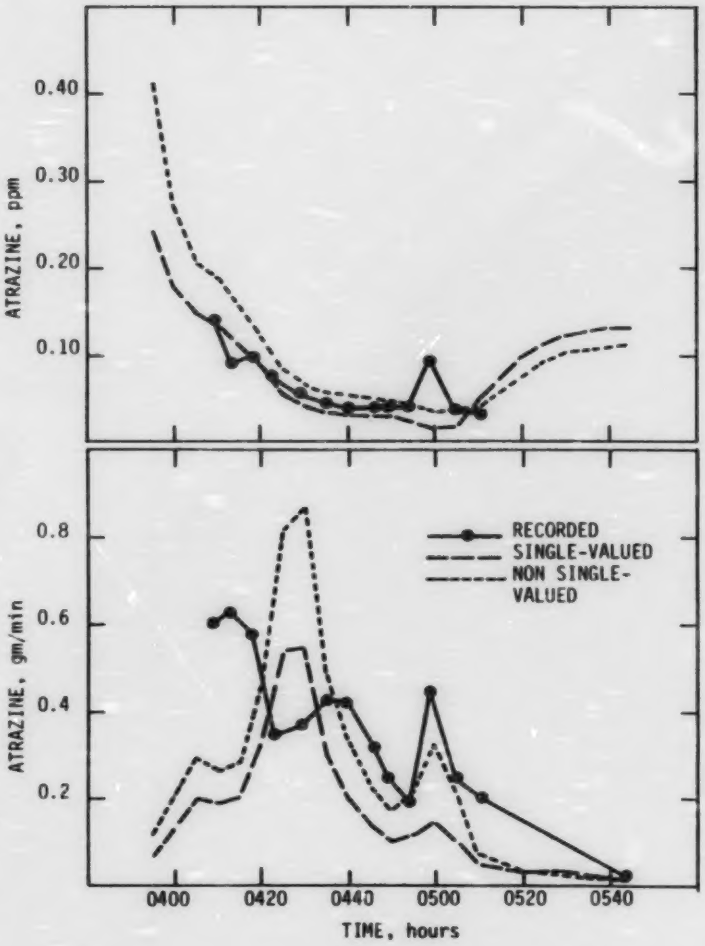


Figure 10.5 Atrazine removal in solution from the P2 watershed for the storm of May 28, 1973

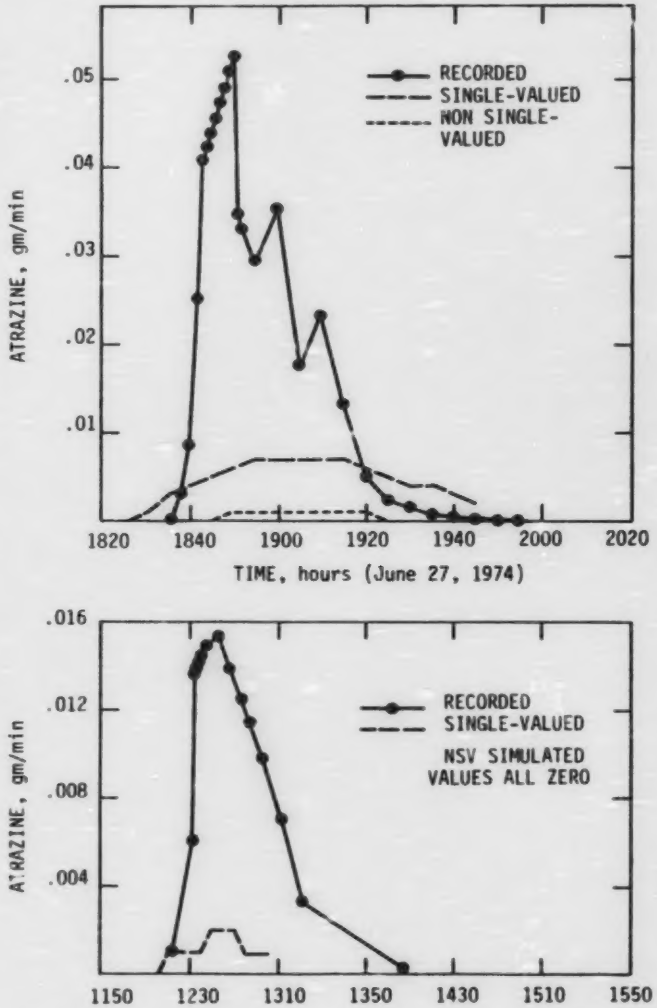


Figure 10.6 Atrazine removal in solution from the P2 watershed for the storms of June 27, and July 27, 1974

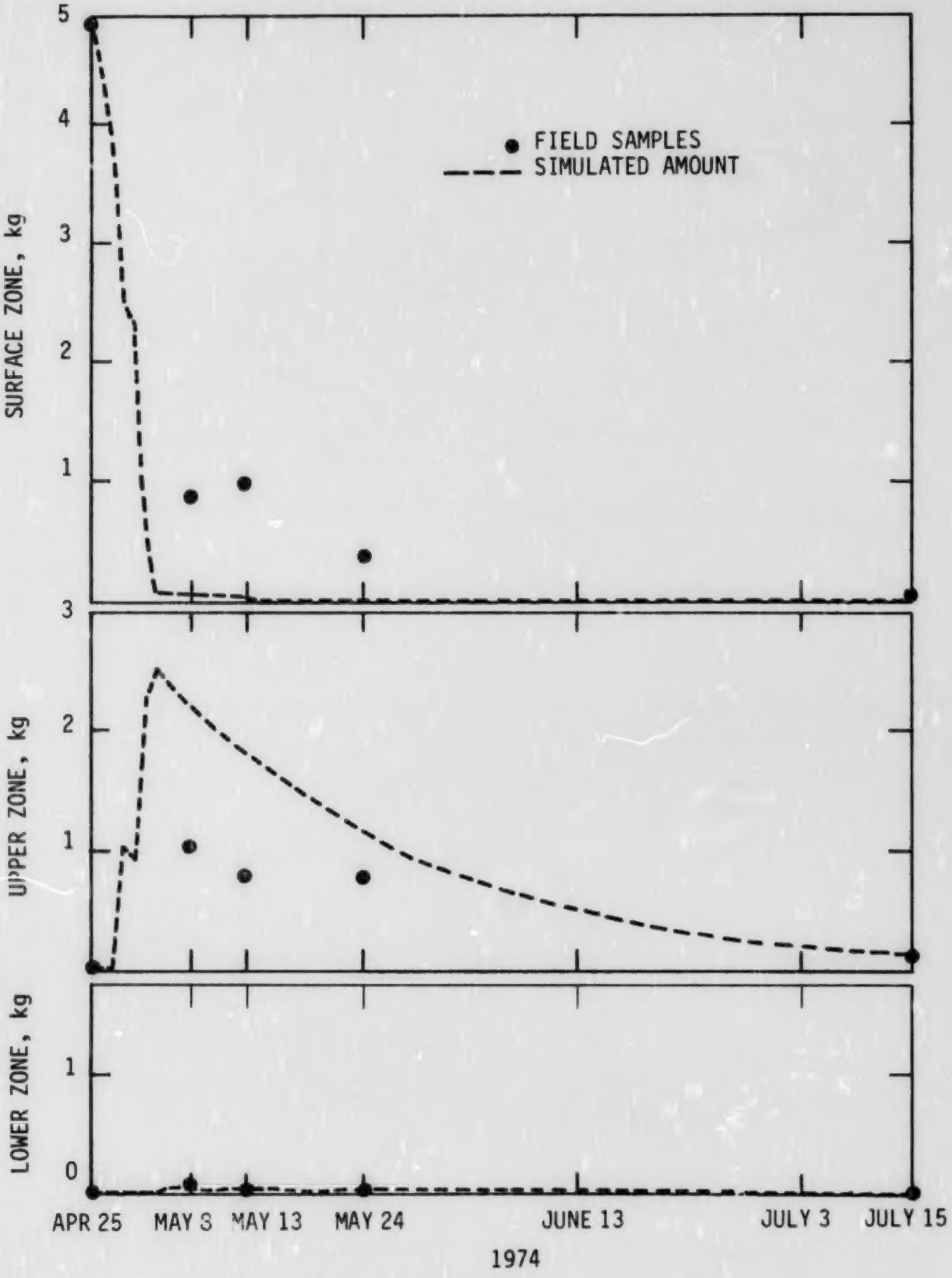


Figure 10.7 Atrazine in soil storage by zone on the P2 watershed

TABLE 10.3 PESTICIDE PARAMETER VALUES

	P2 Watershed		P6 Watershed	
	Atrazine	Paraquat	Atrazine	Paraquat
CMAX	0.000035	0.000010	0.000035	0.000010
DD	0.0	0.0003	0.0	0.0003
K	2.0	120.0	4.0	120.0
N	1.0	2.0	1.0	2.0
NP	2.3	4.6	2.3	4.6
KDG1	1.10	0.002	0.05	0.002
KDG2	0.04	0.002	0.05	0.002
SZDPTH	0.125	0.125	0.125	0.125
UZDPTH	6.125	6.125	6.125	6.125
BDSZ	99.9	99.9	63.7	63.7
BDUZ	99.9	99.9	72.4	72.4
BDLZ	99.9	99.9	99.0	99.0
UZF	3.0	3.0	1.0	1.0
LZF	1.5	1.5	1.0	1.0

TABLE 10.4 PESTICIDE APPLICATIONS

Watershed	Date	Pesticide	Target Rate (kg/ha)	Monitored Rate (kg/ha)
P2	5/11/73	atrazine	3.36	--
	7/29/74	atrazine	3.36	3.81
	5/21/75	atrazine	1.68	1.54
	5/11/73	paraquat	1.53*	2.36
	4/29/74	paraquat	1.53*	2.45
	5/21/75	paraquat	1.53*	1.93
P6	5/22/74	atrazine	4.50	3.95
	11/8/74	atrazine	2.25	3.00
	5/17/75	atrazine	2.25	1.38
	5/22/74	paraquat	1.12*	1.22
	11/8/74	paraquat	1.12*	1.29
	5/17/75	paraquat	1.12*	1.78

* computation based on dichloride salt

considerably better than dissolved pesticide forms. The accuracy of the simulation depends on how well the surface zone and degradation mechanisms are represented. If erosion by particle size is to be implemented (discussion in Section 9) adsorption and desorption of pesticides onto sediment by particle size should also be included. Research has demonstrated a preference of certain pesticides to adsorb onto sediment dependent on particle size and composition. If the ARM Model can take advantage of this knowledge the simulation of pesticides may be improved.

The relative accuracy of using the NSV adsorption/desorption approach over the SV approach cannot be demonstrated until the constants used in the Freundlich equations (K, N, and NP) are determined with more accuracy. Thus, it is recommended that laboratory analysis of this problem be done for all pesticides applied on the Georgia and Michigan watersheds and for these soil types. Once these values are known with more certainty then a more valid comparison of the relative merits of the NSV and SV adsorption/desorption algorithms can be made.

A study of the effects of environmental changes on the behavior of pesticides in the soil would be useful. As discussed in Section 7, temperature and moisture conditions affect pesticide degradation and degradation affects the amount of pesticide runoff. At the Michigan P6 watershed it was seen that winter pesticide simulation was poor, probably because of the model's inability to take into account the effect of low temperature on biological decay of atrazine. Thus, the ability to incorporate environmental effects such as temperature and moisture in pesticide simulation will allow the use of the ARM Model in a greater range of climatic conditions.

SECTION 11

NUTRIENT RUNOFF SIMULATION RESULTS

The goal of the nutrient modeling effort was to test and evaluate the behavior of the nutrient model on the Georgia (P2) and Michigan (P6) watersheds. To accomplish this goal, the hydrology and sediment simulation results (Section 9) provided the transport mechanisms for the nutrient runoff simulation discussed below. Section 8 presented the soil nutrient simulation results which provide the initial conditions and source values for nutrient runoff components. The coupling of the transport mechanisms and soil nutrient storages results in the simulation of nutrient contributions to a stream. This section will present and evaluate the monthly nutrient runoff and the storm event simulation results and discuss the overall functioning of the model. It will conclude with a summary of results and recommendations for further study.

MONTHLY SIMULATION RESULTS

The monthly total removal of nitrogen (N) and phosphorus (P) for the P2 and P6 watersheds, divided into sediment and solution components, is presented in Figures 11.1 and 11.2, respectively. The forms of nitrogen on sediment for both watersheds are illustrated in Figure 11.3, while the forms of nitrogen in solution are presented in Figure 11.4. Figure 11.5 provides the simulated and recorded phosphorus in solution for both watersheds. The corresponding values for these graphs are given in Tables 11.1 and 11.2. All these results should be considered in light of the simulated runoff and sediment values given in Tables 11.1 and 11.2 and in Section 9.

The results should be interpreted with the knowledge that the nutrient related parameters for the P2 watershed were calibrated on both the 1974 and 1975 summer periods. This provided a single set of reaction rates that were subsequently used for both summer periods. Following the calibration, the entire period from April 1974 through April 1975 was simulated to evaluate the model behavior during the nonsummer period. The P6 watershed was calibrated only on the summer 1974 period. The calibrated nutrient reaction rates were then used for the 1975 summer period and provided reasonable results. As on the P2 watershed, a single simulation run was then made from May 1974 to May 1975 to evaluate the nonsummer simulation. The nutrient storages, monthly plant uptake fractions, and soil temperature regression constants were then reset on June 1, 1975 for the summer 1975 simulation.

Some general comments can be made on the simulation of Total P and Total N, as presented in Figures 11.1 and 11.2 and Tables 11.1 and 11.2. Generally

TABLE 11.1 NUTRIENT RESULTS FOR THE P2 WATERSHED

Month		Runoff	Sediment	NO_3-N	NH_4-N		Total N		PO_4-P	Total P
				(Sol)	(Sol)	(Sed)	(Sol)	(Sed)	(Sol)	(Sed)
		(mm)	(kg/ha)	(gm/ha)						
1974 May	Rec	7.6	102.1	57.2	18.2	42.1	222.1	123.8	2.3	150.9
	Sim	18.3	1145.3	437.1	464.0	276.8	901.1	2510.6	33.6	1189.4
June	Rec	41.9	968.0	487.7	901.7	214.4[b]	1897.2	1778.4[b]	74.3	922.5[a]
	Sim	41.4	2138.1	187.2	159.2	918.8	346.4	4997.7	13.4	2155.9
July	Rec	47.0	684.6	100.8[b]	304.4	225.1	1098.0[b]	2361.8	27.2	359.5
	Sim	44.0	600.6	0.0	20.2	239.9	20.2	1346.3	3.4	583.4
Aug	Rec	12.2	104.3	82.4	271.5[c]	69.2	379.5	258.8	10.0	58.8
	Sim	18.7	224.0	21.3	224.0	85.2	245.3	493.1	21.3	213.7
Sept	Rec	0.6	0.9	8.9	0.0	4.8	10.2	12.2	1.0	1.5
	Sim	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oct	Rec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nov	Rec	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dec	Rec	0.1	0.0	1.2	0.2	0.0	5.6	0.0	0.3	0.0
	Sim	0.6	11.2	0.0	3.4	4.5	7.9	26.8	1.1	11.1
1975 Jan	Rec	1.5	3.4	3.0	5.0	2.5	14.6[c]	21.4	6.0	1.2[b]
	Sim	3.1	65.0	46.0	29.1	21.3	75.1	151.1	6.7	197.1
Feb	Rec	9.3	13.2	-	-	-	-	-	-	-
	Sim	20.4	351.9	23.9	216.3	112.1	456.2	821.1	54.9	326.4
Mar	Rec	48.1	59.3	58.5	25.1	233.3	954.8	908.8	90.3	82.4
	Sim	78.5	340.7	473.0	661.3	206.2	1,134.3	1,561.4	176.0	623.8
Apr	Rec	16.5	22.3	16.5	0.0	56.2	432.5	411.1	34.3	18.0
	Sim	27.9	271.2	124.4	192.8	75.1	317.2	614.5	53.8	247.2

(continued)

TABLE 11.1 (continued)

Month		Runoff	Sediment	NO_3-N	NH_4-N		Total N		PO_4-P	Total P
				(Sol)	(Sol)	(Sed)	(Sol)	(Sed)	(Sol)	(Sed)
		(mm)	(kg/ha)	(gm/ha)						
May	Rec	8.9	340.7	67.2	43.7	83.5	172.3	117.2[b]	8.1	218.6
	Sim	22.6	889.8	-	-	-	-	-	-	-
Plant uptake and initial storages were reset for the simulation run beginning June 10.										
June	Rec	41.9	4,124.6	298.4	114.0	547.5	1,214.3	1,083.3	42.5	2,933.5
	Sim	30.0	3,117.5	397.9	273.5	357.5	671.4	1,695.9	40.3	4,083.7
July	Rec	32.3	973.1	183.7	397.8	568.8[c]	893.2	2,465.5[c]	17.5	778.3
	Sim	9.8	401.2	254.4	237.6	384.4	492.0	548.4	14.6	400.8
Aug	Rec	1.6	11.2	103.2	18.3[c]	11.6	124.2[c]	46.6	4.7	15.6
	Sim	0.2	2.3	54.9	21.3	1.1	76.2	1.1	2.2	1.1
Sept	Rec	10.6	90.9	58.3	34.6	183.8[c]	476.8	183.8[c]	15.0	221.5
	Sim	12.4	248.8	552.6	385.6	218.6	938.2	317.7	43.7	419.9
TOTAL except Feb. & May '75	Rec	261.9	7,144.7	1,459.8	2,159.3	2,271.4	7,723.0	9,655.5	325.4	5,544.7
	Sim	285.0	8,565.9	2,548.8	2789.4	2,787.4	5,225.3	14,264.6	410.1	10,127.1

a. Total value is an estimate because of missing samples.
b. Excludes certain minor storm events that were not sampled.
c. questionable value

Sol - solution form
Sed - sediment adsorbed form

TABLE 11.2 NUTRIENT RESULTS FOR THE P6 WATERSHED

Month		Runoff	Sediment	NO_3-N	NH_4-N		Total N		PO_4-P	Avail P	Total P
		(mm)	(kg/ha)		(Sol)	(Sed)	(Sol)	(Sed)	(Sol)	(Sed)	(Sed)
				(gm/ha)							
1974											
June	Rec	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.3	2.	527.6	28.1	0.0	555.7	5.1	32.6	1.1	2.3
July	Rec	3.0	389.	116.8	0.1	0.3	220.9	1177.4	0.3	1.6	31.0
	Sim	0.5	9.	166.1	44.9	0.0	211.0	18.7	9.0	2.2	8.5
Aug	Rec	25.8	796.	196.3	123.9	63.0	726.3	2506.3	67.4	220.3	1424.5
	Sim	19.8	928.	389.5	86.4	64.0	475.9	2196.8	68.5	208.8	1064.3
Sep	Rec	0.8	35.	4.3	16.6	2.4	22.1	99.6	2.8	10.9	16.3
	Sim	2.7	72.	86.4	37.0	3.4	123.4	153.8	38.2	15.7	76.4
Oct	Rec	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nov	Rec	0.6	10.	4.5	5.1	0.5	11.4	22.5	1.3	3.3	4.4
	Sim	4.3	78.	1107.9	209.9	3.4	1317.8	156.5	103.3	16.8	75.8
Dec	Rec	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	0.2	0.	120.1	0.0	0.0	120.9	0.0	12.3	0.0	0.0
1975											
Jan	Rec	33.2	248.	218.4	359.5	-	897.3	573.4	77.4	-	410.6[a]
	Sim	35.3	753.	862.1	504.0	31.4	1366.2	1668.2	390.6	390.6	661.0
Feb	Rec	35.1	244.	330.1	664.8	-	1505.4	727.4[a]	165.5	-	474.4[a]
	Sim	12.6	101.	490.5	241.3	2.3	731.8	212.6	299.7	21.3	99.5
Mar	Rec	26.5	723.	364.9	647.3	-	1479.9	2370.0[a]	139.5	-	1558.5[a]
	Sim	11.5	72.	451.2	177.4	0.0	628.6	148.0	217.8	14.6	69.6
Apr	Rec	88.7	12,315.	674.	625.	243.[b]	2133.	31510.	590.	1378.[b]	16,538.
	Sim	100.3	2,640.	745.	260.	14.	1025.	5390.	594.9	509.6	2,604.9
May	Rec	0.1	3.	1.5	1.0	-	4.0	5.9	0.4	0.4	3.8
	Sim	0.6	91.6	-	-	-	-	-	-	-	-
		Plant uptake, initial storages, and soil temperature regression constants were reset for the simulation beginning June 1.									
June	Rec	5.8	410.	40.5	60.6	12.9	178.1	1035.4[a]	49.0	41.1	644.5[a]
	Sim	2.6	54.	617.4	113.3	1.1	730.7	127.0	47.1	4.5	78.8
July	Rec	0.1	2.	0.9	0.8	-	2.5	8.3	0.4	0.3	4.1
	Sim	0.7	13.	275.0	68.5	0.0	343.5	28.3	18.0	1.1	18.7

(continued)

TABLE 11.2 (continued)

Month		Runoff	Sediment	NO_3-N	NH_4-N		Total N		PO_4-P	Avail P	Total P
		(mm)	(kg/ha)	(Sol)	(Sol)	(Sed)	(Sol)	(Sed)	(Sol)	(Sed)	(Sed)
				(gm/ha)							
Aug.	Rec	50.0	1629.	208.0[a]	290.8[a]	36.4[a]	747.4[a]	3959.6[a]	284.9[a]	99.9[a]	2191.6[a]
	Sim	62.6	2329.	354.7	191.9	56.1	546.6	5430.0	275.0	202.1	3334.3
Sept	Rec	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sim	3.1	18.	68.5	41.5	0.0	100.0	37.4	83.1	1.2	22.8
TOTAL	Rec	269.5	16,801.	2,158.7	2,794.5	-	7,924.3	43,989.9	1,390.8	-	23,297.9
Except May	Sim	256.5	7,069.	6,262.0	2,024.2	175.7	8,277.1	15,5 2.4	2,300.1	1,389.6	8,116.9

a. Total value is an estimate because of missing samples
b. Excludes certain minor storm events that were not sampled.

Sol - Solution form
Sed - Sediment adsorbed form

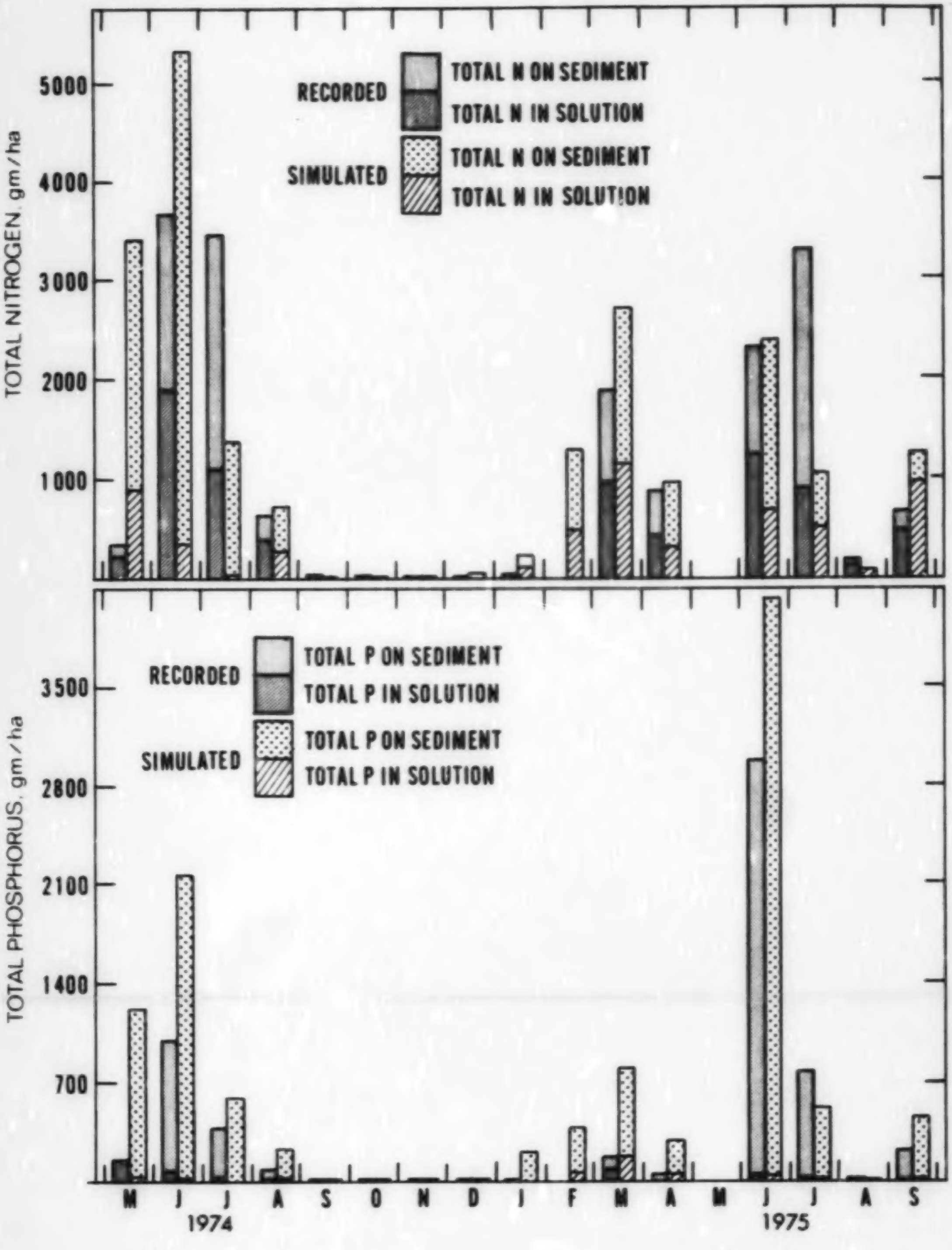


Figure 11.1 Monthly total nitrogen and phosphorus runoff from P2 watershed

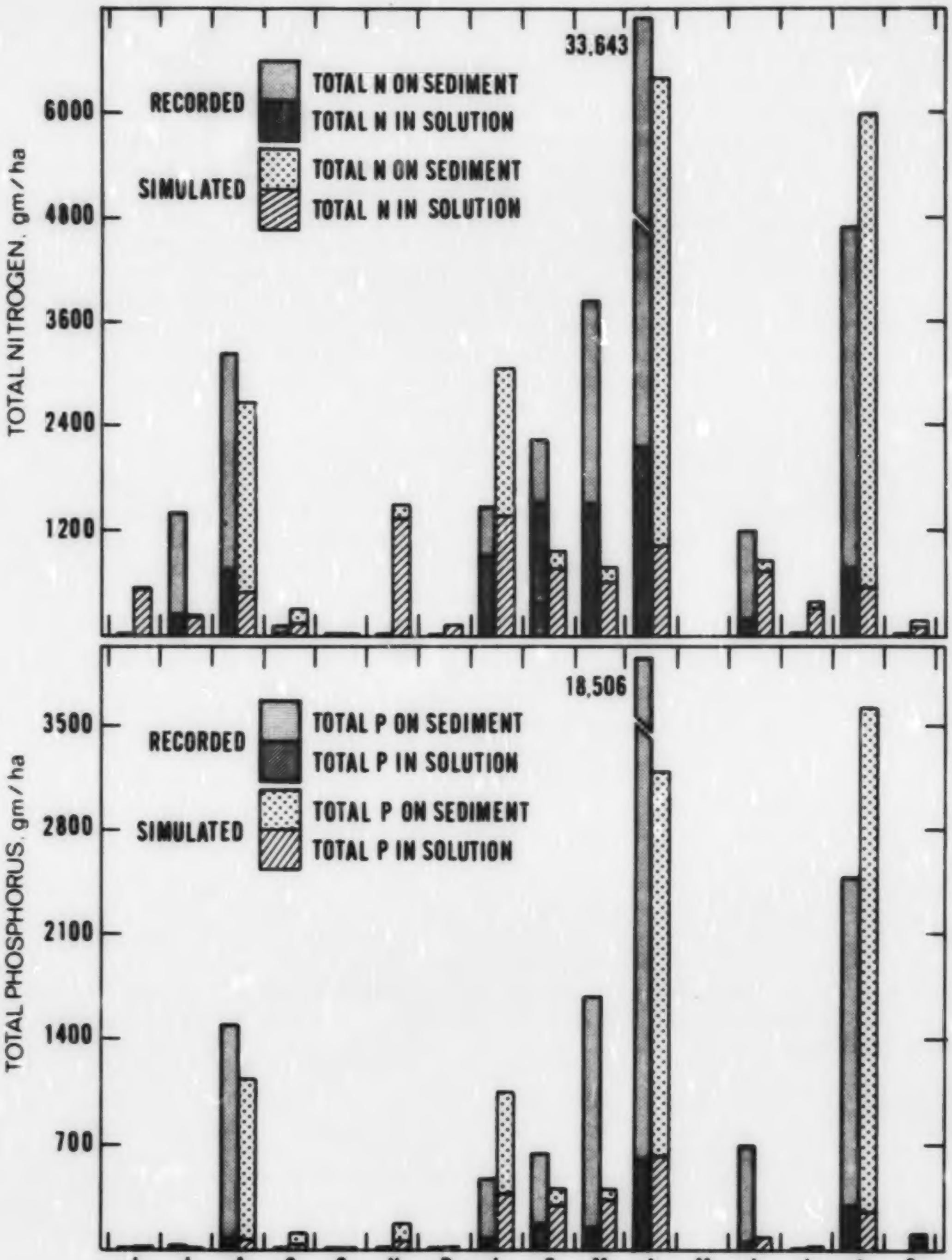


Figure 11.2 Monthly total nitrogen and phosphorus runoff from the P6 watershed

the accuracy of the simulation results for total nutrients corresponds well with that for runoff and sediment removal. For example, when sediment was under simulated on the P6 watershed for April 1975 so was Total N and Total P. For some of the monthly results this relationship to runoff and sediment simulation was not as strong. Moreover, in some cases runoff and sediment loss are over simulated and nutrients are under simulated. Examples of this behavior occur on the P2 watershed for the months of July 1974 and June 1975. In July 1974 runoff is high, sediment removal is low, but Total N removal is low and Total P removal is high. In June 1975, both runoff and sediment simulation is low while Total N and Total P removal are high. A similar event occurs on the P6 watershed where during August 1974 runoff is under simulated, sediment loss over simulated, yet both Total N and Total P are under simulated. These seeming inconsistencies are due to particular solution or sediment nutrient forms comprising most of the observed nutrient loss and corresponding discrepancies in simulating the associated transport mechanism.

In general, the simulation of monthly Total N and Total P for the entire test period gives reasonable results as an initial test of the nutrient algorithms. For the entire simulation period the Total N removal on the P2 watershed is simulated within 13 percent of the recorded value, while Total P is over simulated by 80 percent. The over simulation was partially caused by the over simulation of sediment loss. For the P6 watershed, with the exclusion of April 1975, the Total N and Total P removals for the entire simulation period are good: within 6 percent of the recorded values.

The sediment portion of the runoff for both watersheds carries more nitrogen and phosphorus than does the solution component of the runoff. However, the solution nitrogen does at times contribute to much of the Total N removal. Phosphorus in solution is a smaller portion of the Total P washoff on the P2 watershed than on P6. This is likely caused by less phosphorus fertilizer applied on P2.

The sediment nutrients are either organic or inorganic forms. Measurements of inorganic phosphorus on sediment were not made except for some analysis of Available P (Table 11.2). It is assumed that most of the phosphorus associated with the sediment was in the organic form. Most of the simulated phosphorus is organic. Thus, the results presented and discussed for Total P can be considered to be similar to the simulation of the Organic P content of the sediment.

Breakdown of the forms of Total N attached to the sediment are shown in Figure 11.3. Much more sediment associated nitrogen is organic than inorganic. Like phosphorus, the Organic N simulation is similar to the Total N results. The accuracy of the simulation depends on the accuracy of the sediment simulation. However, the simulation results for the inorganic fraction, NH_4-N, varies. The largest portion of NH_4-N is found in the summer after spring fertilization. Generally, the simulation of NH_4-N is reasonably good, particularly when the sediment simulation is good.

The solution nutrient simulation results like the sediment results are strongly influenced by the simulation of the transport mode. The runoff

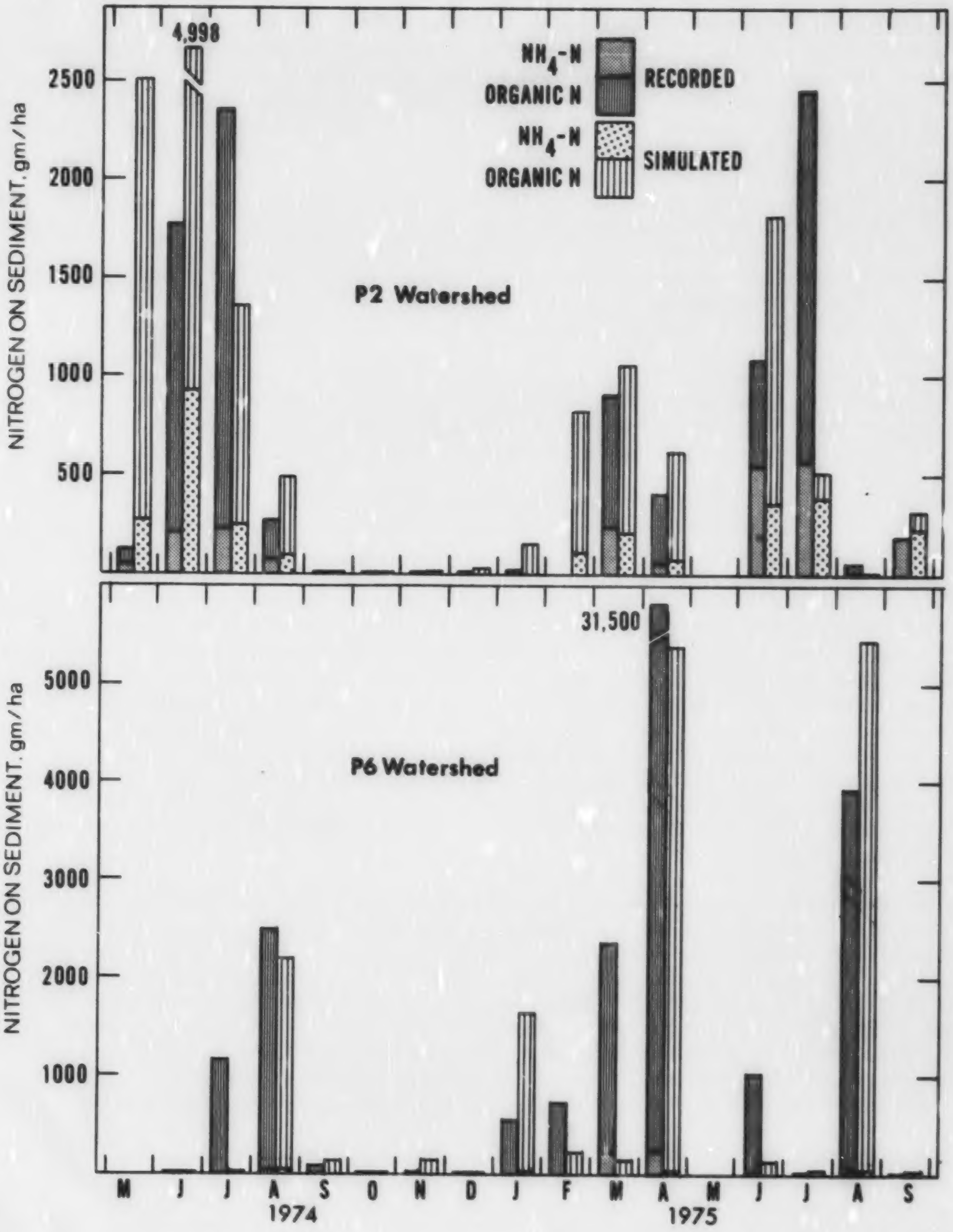


Figure 11.3 Monthly organic N and NH_4 on sediment from the P2 and P6 watersheds

simulation, discussed in Section 9, influences the amount of nutrient removed in solution. Most of the soluble nutrient removal comes from the interflow component of runoff. Hence, the interflow hydrology parameter, INTER, has a major impact on the solute runoff simulation. For example, INTER for P2 was reduced from 0.70 to 0.59 for the nutrient simulation. This resulted in a minor difference in the runoff simulation (less than 3 percent increase) during the period of May 1, 1974 through September 30, 1974. However, this reduction in INTER decreased NO_3-N in solution from 4.52 kg/ha to 0.64 kg/ha during this period.

The simulated and recorded forms of nitrogen in solution are shown in Figure 11.4. The nutrient model does not simulate Organic N in solution even though the recorded results show that there can be large amounts of Organic N relative to inorganic forms. The large amounts of Organic N found in the water phase of the runoff may have been actually attached to sediment particles that passed the filtering process in the laboratory analysis. Organics may also have occurred in solution by the disassociation of sediment organics in the runoff samples.

NO_3-N and NH_4-N in solution are simulated by the model. The overall result of the NO_3-N simulation is to over simulate NO_3-N on the P6 watershed and slightly over simulate it on P2. The over simulation of P6 NO_3-N runoff cannot be directly attributed to the runoff since it is under simulated. For P6, the simulation of NO_3-N is worse than average during the months of June and November, 1974 and June and July, 1975. The simulated soil storages (Figure 8.5) of NO_3-N are higher than recorded in November and lower than observed in both Junes, but the July storage is close to the observed values. However, the soil storage and runoff results do not account for the over simulation of NO_3 for the three summer months. This situation indicates a need to further study the transport mechanisms. The influence of the interflow parameter on NO_3-N runoff simulation appears to be more important than the soil storage simulation. The November over simulation of NO_3-N can be explained by the over simulation of both runoff and soil storage.

The simulation of NO_3-N for the P2 watershed generally follows the hydrology simulation, except for some of the summer months. The effect of the over simulation of soil NO_3-N (Figure 8.2) during the winter did not compound the effect of the over simulation of the runoff. NO_3-N in the summer months is slightly over simulated even considering the effect of the runoff results. The main exception is the under simulation of NO_3-N in July 1974. No NO_3-N in solution occurs during this month because no interflow is simulated. The inconsistent NO_3-N simulation indicates that further study of the hydrology simulation for the P2 watershed and the transport mechanisms is needed.

The simulation of NH_4-N in solution for the entire simulation period is good. The recorded NH_4-N in solution for both watersheds is slightly greater than the NO_3-N. The results are generally better for NH_4 -N than NO_3-N on both of the watersheds, although the NH_4-N simulation results generally follow the NO_3-N trends. However, for the winter period on the P2 watershed, NH_4-N is over simulated; very little NH_4-N is

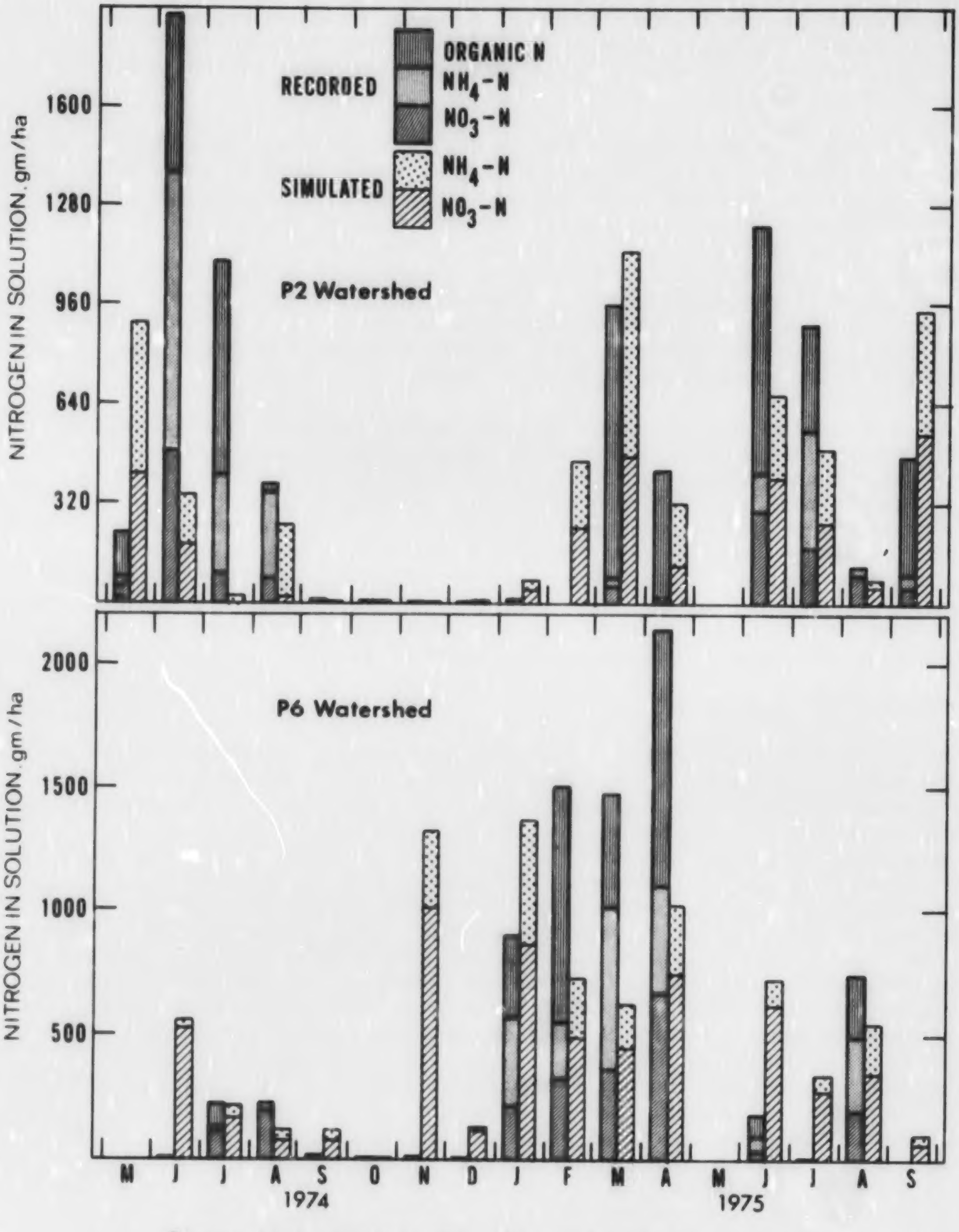


Figure 11.4 Monthly NH_4, NO_3, and organic N removal in solution from the P2 and P6 watershed

recorded in the P2 runoff during this period. The over simulation is perhaps due to over mineralization of organics to NH_4-N in the soils during this period. Much more NH_4-N is recorded for the Michigan P6 watershed during the winter because of fertilization in November and the possibility of NH_4-N in the snow.

Monthly PO_4-P in solution is shown in Figure 11.5. Much more PO_4-P is in solution from the P6 watershed than from P2 mainly because more fertilizer was applied to P6: 224 kg/ha compared to 54 kg/ha. Although some inconsistencies exist, the overall simulation of solution PO_4-P from the P2 watershed is good, particularly in view of the slight over simulation of runoff. The P6 simulation of PO_4-P is high, mostly because of the over simulation of the winter period. However, the P6 summer months are over simulated when the recorded values are less than 3 gm/ha. Otherwise the three major summer runoff months of August 1974 and June and August 1975 for P6 are well simulated for PO_4-P in solution.

The nutrient model at present simulates monthly results of nutrients on sediment better than nutrients in solution. The value of a more accurate sediment than solution nutrient simulation will depend on whether short term or long term effects are most important. Soluble inorganic nutrients have a more immediate impact on water quality than the sediment-associated nutrients since they are more readily used by algae than either the organic or sediment forms. Thus, soluble nutrients can directly contribute to accelerated eutrophication. However, over the longer term organics and sediment-associated inorganics can decompose and release inorganics in solution available for stimulation of aquatic growth.

STORM EVENT SIMULATION

Analysis of storm event simulation results is needed to determine how well the model is representing the separate solution and sediment nutrients in relation to their transport components. Figures 11.6 to 11.11 present the simulated and recorded values for the June 11, 1975 storm on the P2 watershed. Figures 11.12 to 11.17 show analogous results for the August 27, 1974 storm on the P6 watershed. The results are presented in both concentration and mass removal (gm/min) units. Also, each graph pertains either to the solution or sediment transport mode of the specific component. Other storm event graphs of nutrient simulation results are contained in Appendices B and C. As is noted in the discussion of the monthly results, the event graphs should be viewed relative to the corresponding runoff and sediment graphs in Section 9 and the appendices.

In order to evaluate the storm events simulations, an explanation of the recorded data is needed. Each recorded data point is the mean concentration or mass removal since the previous sample. If a long time span occurs between samples, intermediate values can vary considerably. For example, in Figure 11.6 a recorded concentration of 1430 ppm at time 20:02 is actually an average value of all the concentrations of TKN on sediment from time 1917 to 2002. The actual values vary significantly about the mean of 1430 ppm. This is especially true if there are significant variations in runoff or sediment transport in the intervening

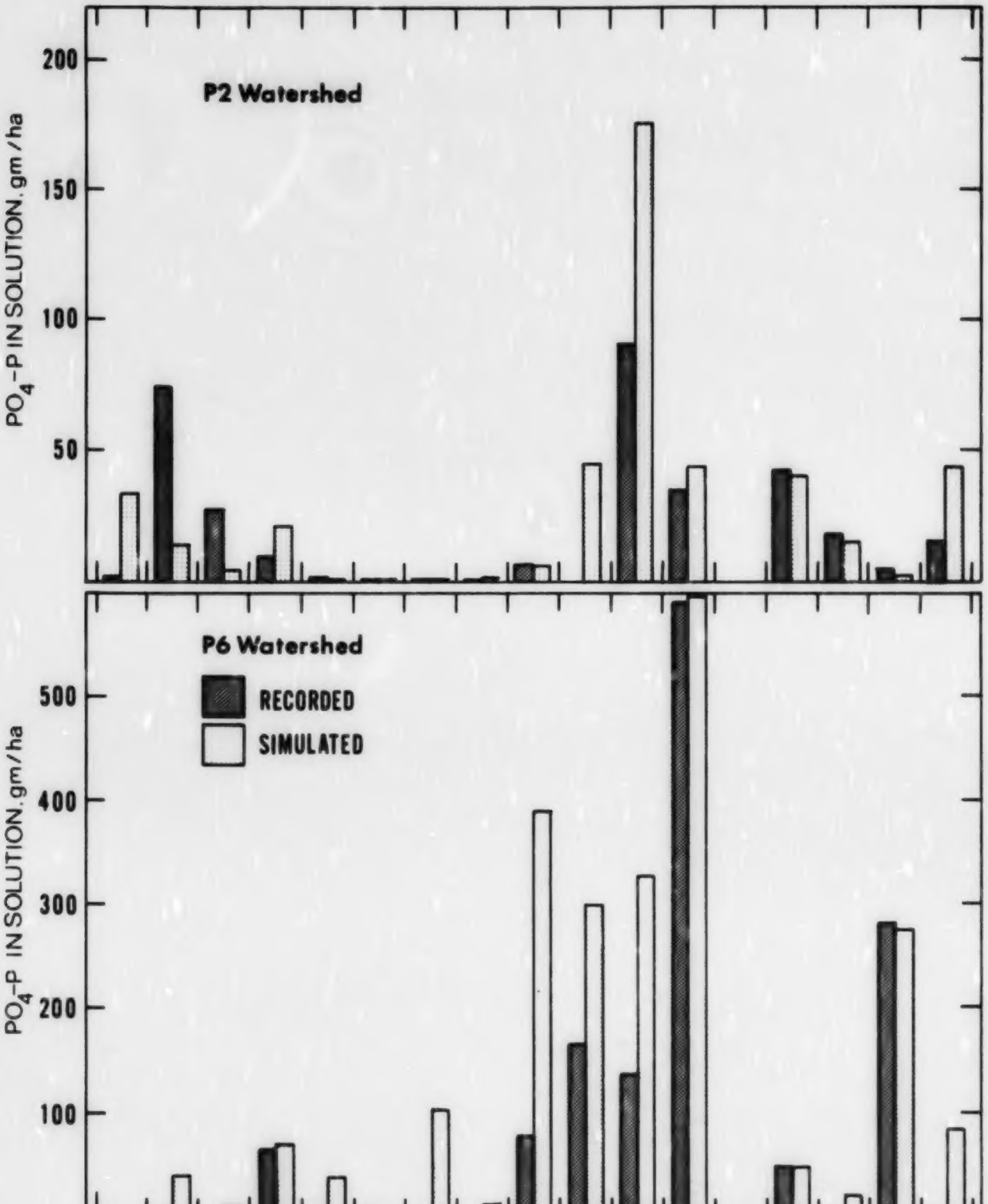


Figure 11.5 Monthly total PO$_4$ removal in solution from the P2 and P6 watersheds

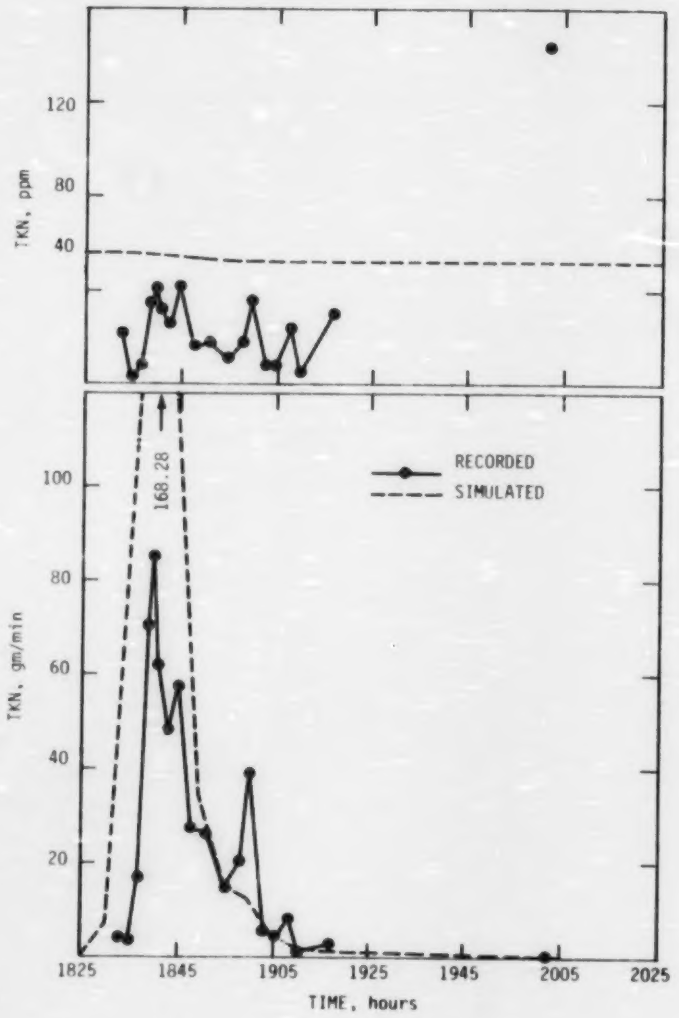


Figure 11.6 TKN removal on sediment from the P2 watershed for the storm of June 11, 1975

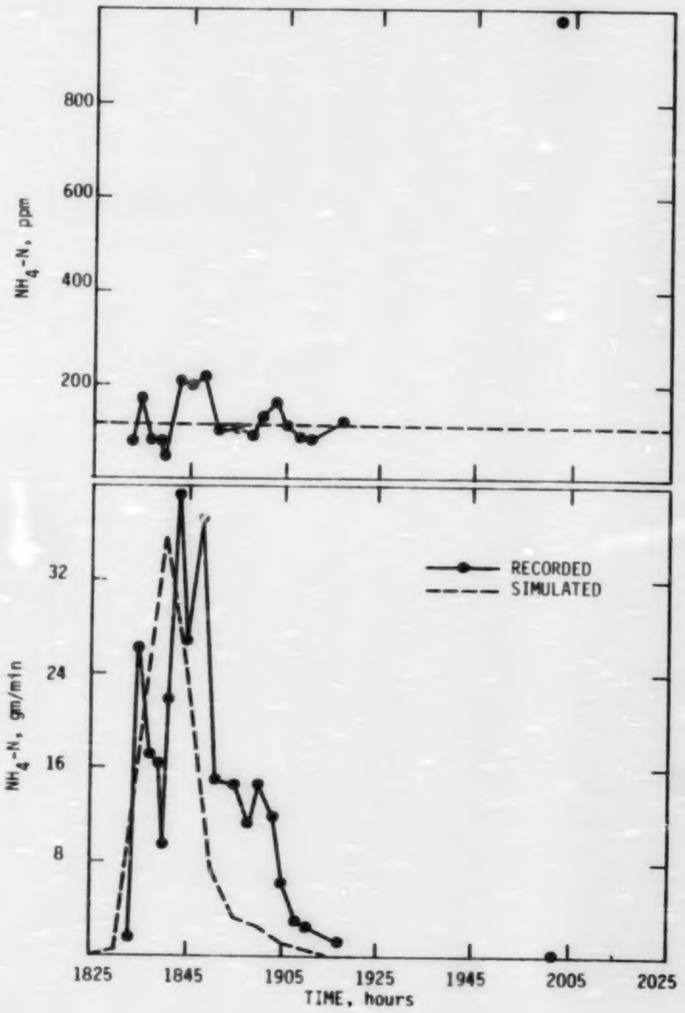


Figure 11.7 NH_4 removal on sediment from the P2 watershed for the storm of June 11, 1975

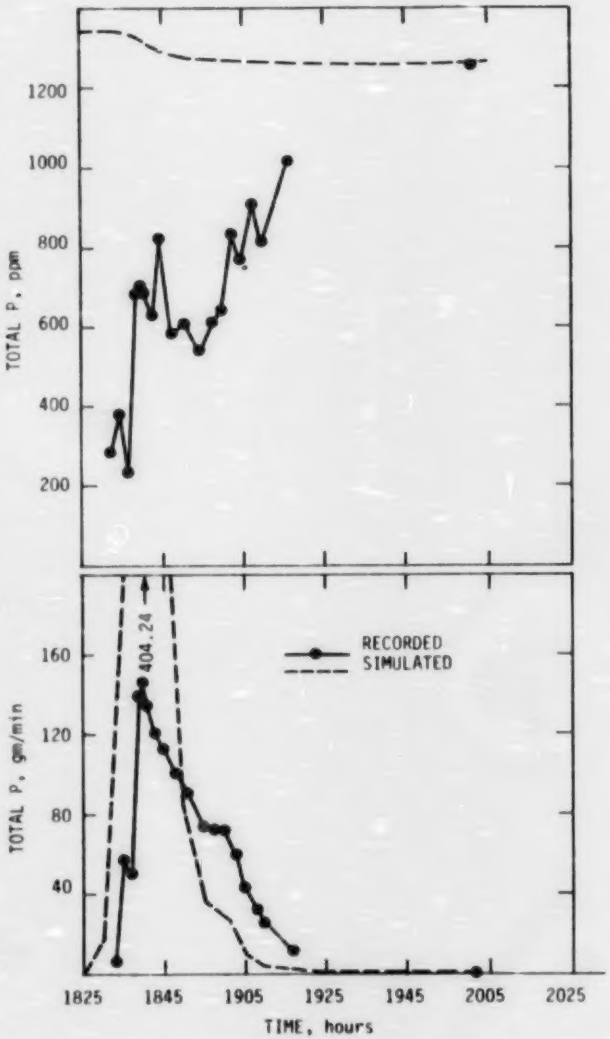


Figure 11.8 Total P removal on the sediment from the P2 watershed for the storm of June 11, 1975

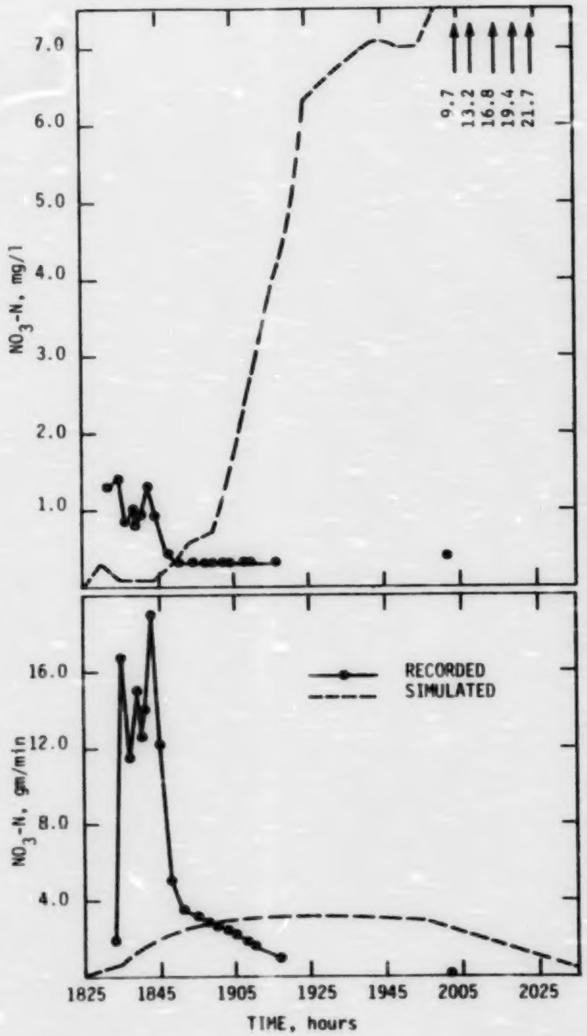


Figure 11.9 NO_3 removal in solution from the P2 watershed for the storm of June 11, 1975

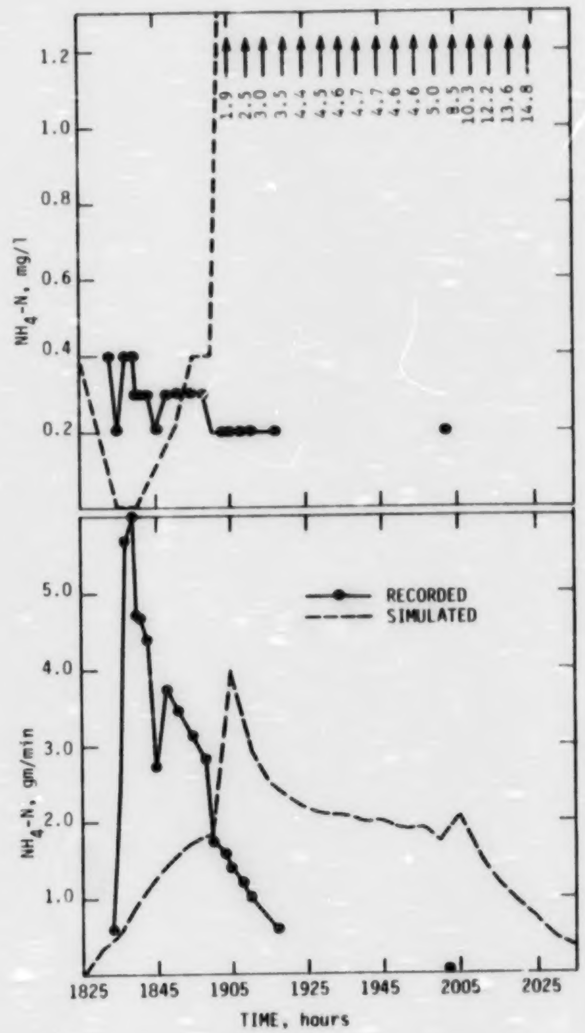


Figure 11.10 NH4 removal in solution from the P2 watershed for the storm of June 11, 1975

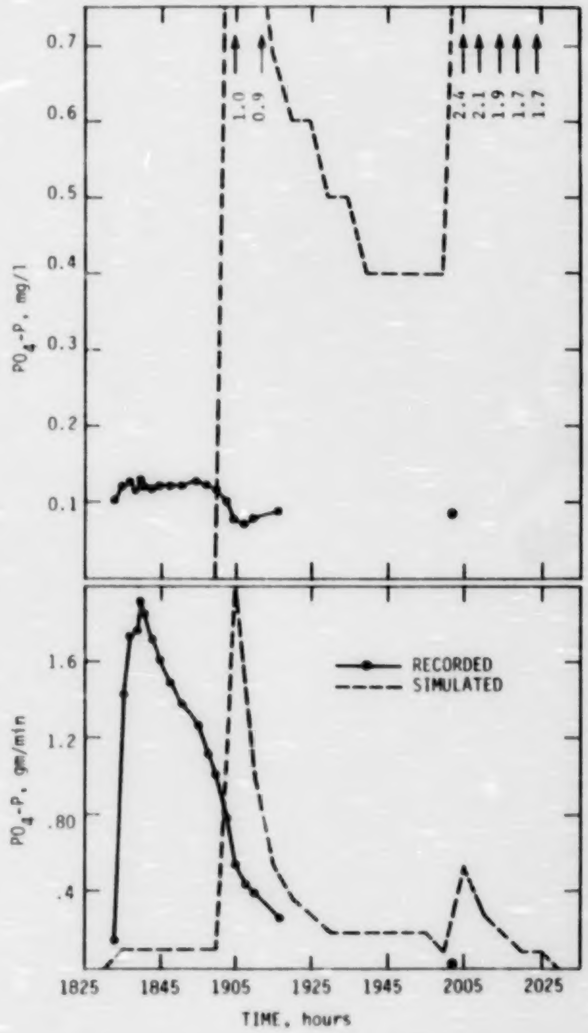


Figure 11.11 PO4 removal in solution from the P2 watershed for the storm of June 11, 1975

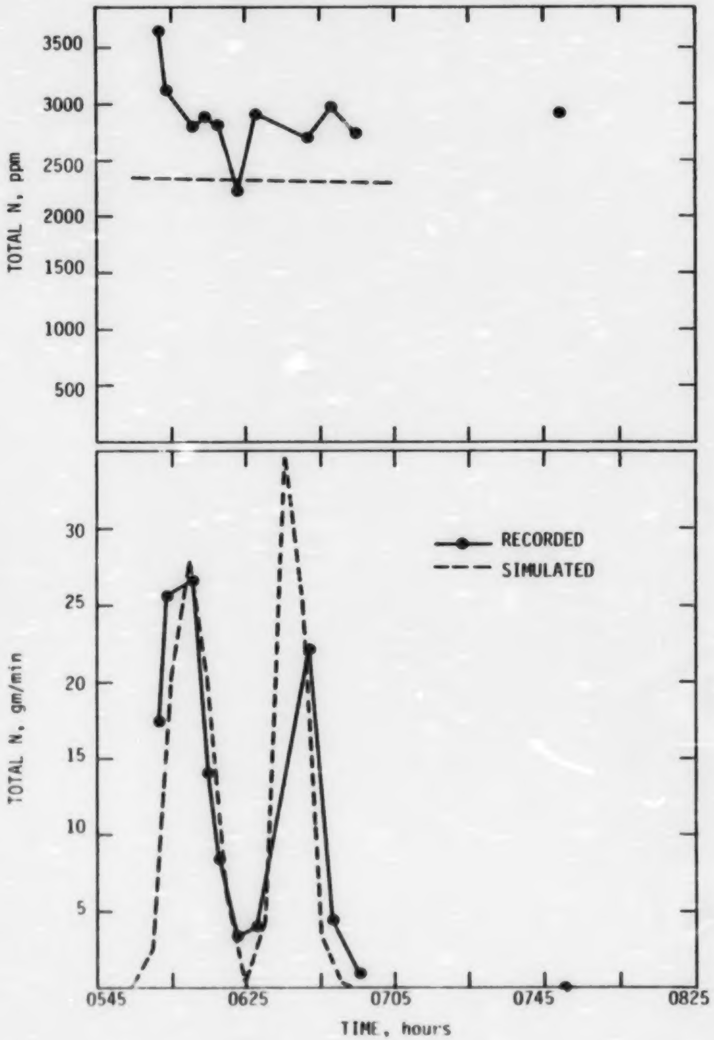


Figure 11.12 Total N removal on sediment from the P6 watershed for the storm of August 27, 1974

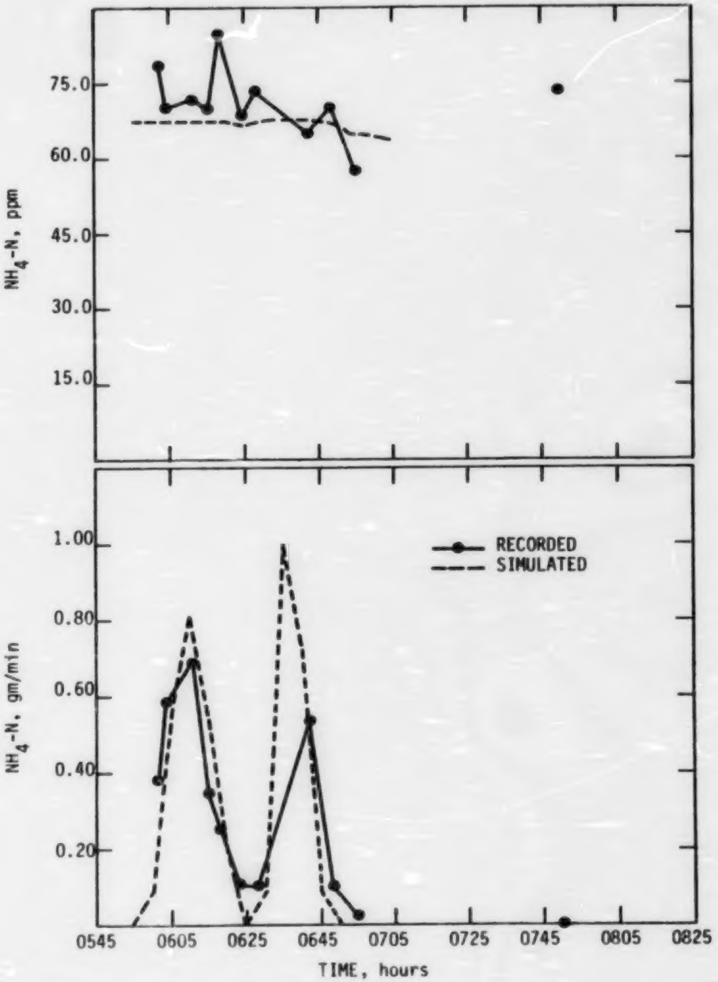


Figure 11.13 NH_4 removal on sediment from the P6 watershed for the storm of August 27, 1974

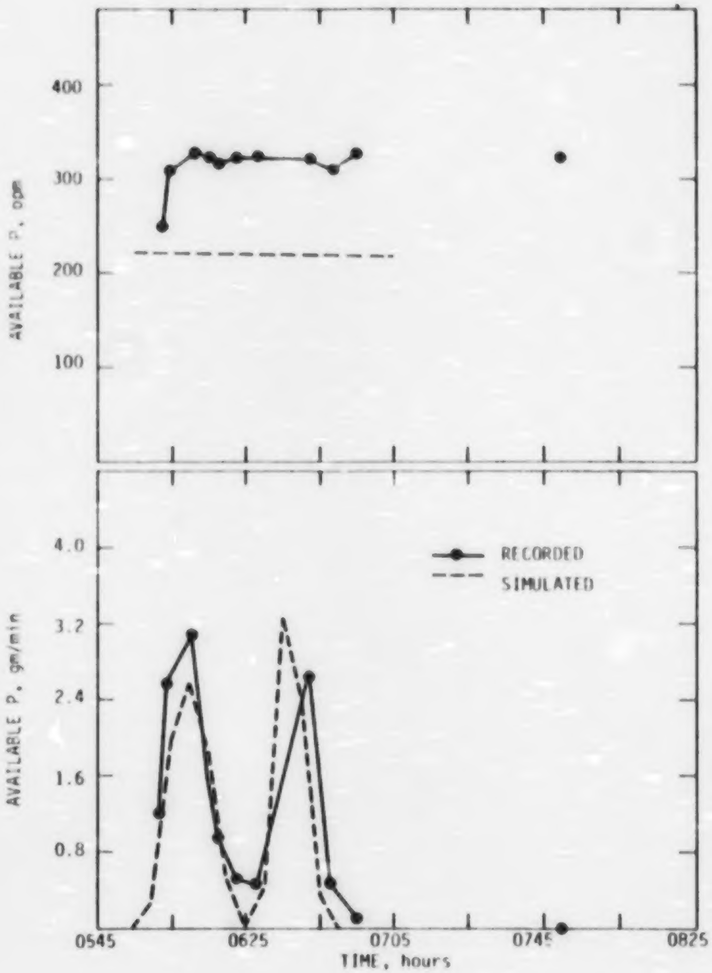


Figure 11.14 Available P removal on sediment from the P6 watershed for the storm of August 27, 1974

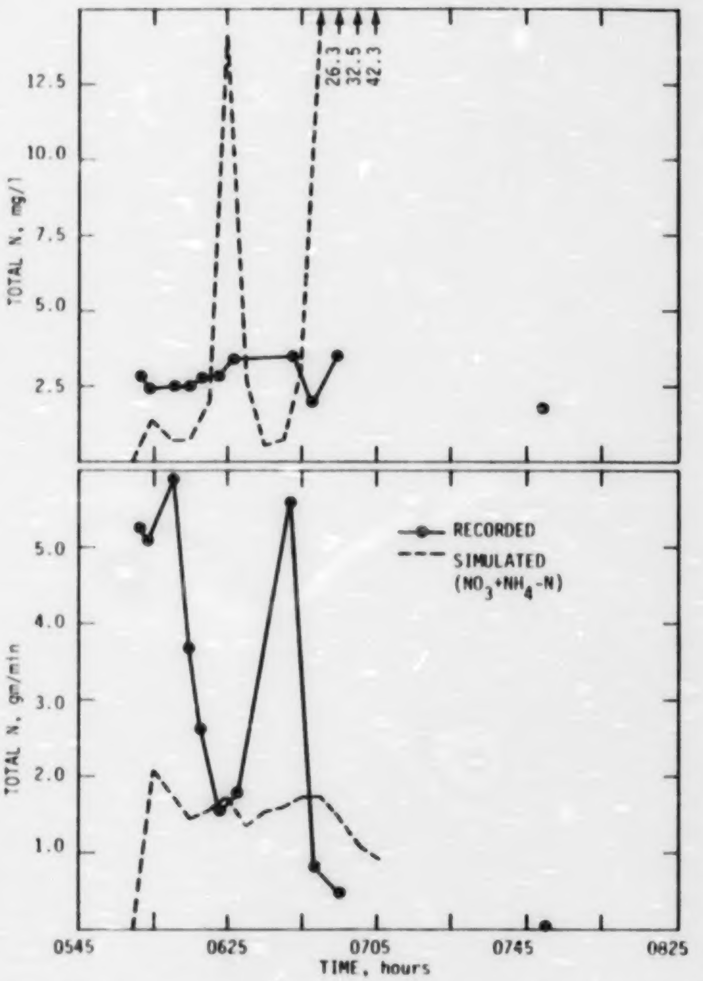


Figure 11.15 Total N removal in solution from the P6 watershed for the storm of August 27, 1974

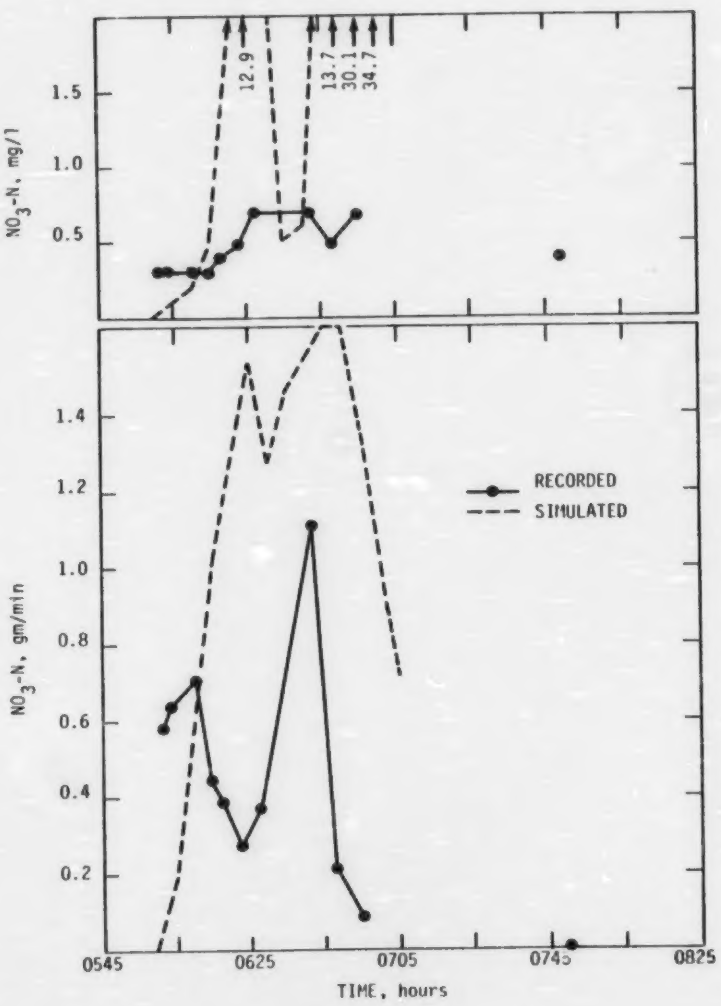


Figure 11.16 NO$_3$ removal in solution from the P6 watershed for the storm of August 27, 1974

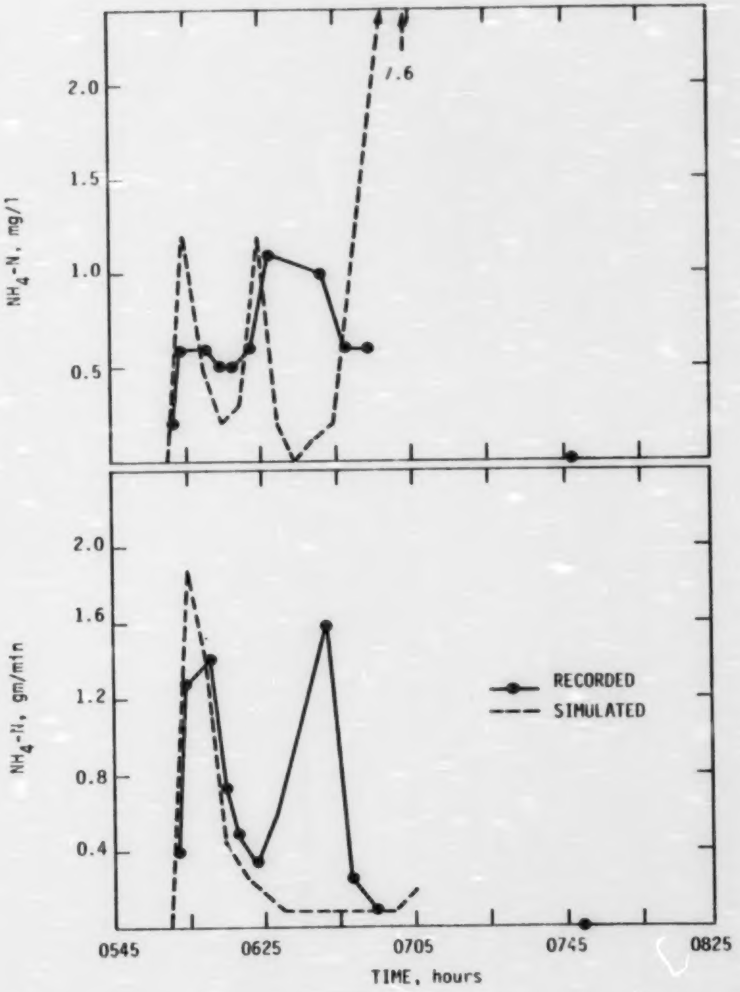


Figure 11.17 NH$_4$ removal in solution from the P6 watershed for the storm of August 27, 1974

period as occurs near the end of a storm event. Hence, for such long intervals between samples, the recorded data points are not connected.

Some general conclusions can be made concerning all the individual storm event results. The summer nutrient simulation is generally better than the winter. The poor winter nutrient simulation is partially due to inaccurate runoff, sediment, and soil temperature simulation. Nutrient simulation on the P6 watershed is also generally better than on P2. This is true for both the sediment and solution nutrient forms. The poor sediment nutrient simulation on P2 is because the concentration of nutrients varied from one storm event to the next more than it did for P6, for which the model simulates the concentration as remaining fairly stable.

The less accurate soluble nutrient simulation on the P2 watershed compared to P6 is because interflow is a smaller portion of total runoff and is more variable. Consequently, soluble nutrients transported mostly in interflow demonstrate the same highly variable nature as the simulated interflow component. This is particularly noticeable in the concentration graphs towards the end of a storm event. For example, NO_3-N concentration in Figure 11.9 becomes relatively large toward the end of the June 11 event. The other soluble nutrients behave similarly to some degree. This can be explained by the fact that interflow, which contains most or all of the soluble nutrients in a more concentrated form than surface runoff, makes up most of the flow towards the end of the storm event. This results in a higher concentration at the end of the storm event than earlier when the flow is diluted by surface runoff. Thus the discrepancies in the soluble nutrient simulation are the direct result of interflow fluctuations. However, the total mass removed from the watershed which is less affected by concentration variations is generally within the range of the recorded values.

NO_3-N is the most difficult solution component to simulate. This is particularly noticeable in the P6 storm results where large variations occur. NO_3-N is difficult because it is affected by many transformations as well as being soluble and thereby easily transported by and in the water. The other nutrients simulated in solution, NH_4-N and PO_4-P, do not undergo as many transformations and are also found in adsorbed form. Since the adsorbed form is usually more stable than the solution form, NH_4-N and PO_4-P are simulated somewhat better than NO_3-N.

All the solution nutrient results including NO_3-N are closer to the recorded values in mass per minute than in concentration (ppm). Since nutrients are not toxic to aquatic life in these small quantities, the simulation of total mass of nutrients in the runoff is considered more crucial than concentration. Moreover, eutrophication which occurs most readily in lakes is dependent more on the total nutrient input than on localized storm concentrations. Thus, simulation of the total mass loading of nutrients should be the primary goal of nutrient modeling in the runoff. The simulation of nutrient loadings with the ARM nutrient algorithms meets this goal since mass loadings are simulated better than instantaneous concentrations.

The simulation of nutrients on sediment, which affect long term eutrophication, is simulated more consistently than soluble nutrients. The concentration of nutrients on sediment in the runoff is simulated as being equal to the concentration in the surface soil zone. This would be modified if selective or particle size erosion could be simulated and incorporated into the ARM Model. Then the nutrient concentration in runoff would be dependent on the nutrients' preference for specific particle sizes and the amounts of these particles removed by runoff from the surface zone. However, with the current version of the model the simulated concentration of nutrients on the soil varies little during a storm event. The mass of nutrient removed on the sediment will still vary depending on how much sediment is being removed during the time period simulated. The storm event simulation results of the sediment-associated nutrient concentration and mass removal (shown in Figures 11.6-11.8 and 11.12-11.14) are quite good. However, for the other major events contained in Appendix B and C, the results show greater variations due primarily to discrepancies in the sediment loss simulation. Nevertheless, the overall simulation of sediment associated nutrients for storm events is better than soluble nutrients and is reasonably close to the recorded values.

SUMMARY

The nutrient model provides a reasonable framework for simulation of nutrient runoff. The results show that the model can be calibrated to a variety of situations. The soil storage simulation provides a reasonably accurate representation of the soil nutrients which are the sources for nutrient components in runoff. Nutrient simulation is found to rely heavily on the hydrology and sediment simulation. Within the present framework of the nutrient model, the accuracy of the nutrient simulation is a direct function of the ability to correctly simulate runoff and sediment loss. Overall, the ARM nutrient model is able with proper calibration to give reasonable estimates of nutrient mass in runoff. However, further study is needed in the area of nutrient transport through surface and subsurface pathways. This involves the study of surface and upper zone relationships, especially soil moisture, surface runoff, and interflow simulation. Even though the nutrients on sediment are simulated better than those in solution, the relationships of nutrient components to erosion processes should be studied. The behavior and transport of nutrients at the soil surface is an important topic for future research. With this additional knowledge, the ARM Model could more accurately simulate nutrients in the soil and in the runoff.

REFERENCES

U.S. Army Corps of Engineers. 1956. Snow Hydrology, Summary Report of the Snow Investigations. North Pacific Division. Portland Oregon. 437 p.

Anderson, E.A. 1968. Development and Testing of Snow Pack Energy Balance Equations. Water Resour. Res. 4(1):19-37.

Anderson, E.A., and N.H. Crawford. 1964. The Synthesis of Continuous Snowmelt Runoff Hydrographs on a Digital Computer. Department of Civil Engineering, Stanford University. Stanford, California. Technical Report No. 36. 103 p.

Black, C.A. 1968. Soil-Plant Relationships. John Wiley and Sons, Inc., New York. 792 pp.

Broadbent, F.E., and F. Clark. 1965. Denitrification. In: Soil Nitrogen, W.V. Bartholomew and F.E. Clark (eds.), Madison, Wis., Am. Soc. Agron. Agronomy Monograph No. 10. p. 344-359.

Crawford, N.H., and A.S. Donigian, Jr. 1973. Pesticide Transport and Runoff Model for Agricultural Lands. Office of Research and Development U.S. Environmental Protection Agency, Washington D.C. EPA 660/2-74-013. 211 p.

Crawford, N.H., and R.K. Linsley. 1966. Digital Simulation in Hydrology: Stanford Watershed Model IV. Department of Civil Engineering, Stanford University. Stanford, California. Technical Report No. 39. 210 p.

Davidson, J.M., and E.D. Chin Choy. 1974. Diurnal Soil Temperture Model for Cecial Soil. Supplement to Project No. R-899364 Program Element 1BB039. 16 pp.

Davidson, J.M., and P.S.C. Rao. 1976. Soil Science Department. University of Florida, Gainesville, Florida. Personal communication on February 5, 1976.

DeVries, D.A. 1958. Simultaneous Transfer of Heat and Moisture in Porous Media. Trans. Amer. Geophys. Union 39(5):909-916.

Donigian, A.S., Jr., and N.H. Crawford. 1976. Modeling Pesticides and Nutrients on Agricultural Lands. Environmental Research Laboratory, Athens, Georgia. EPA 600/2-7-76-043. 317 p.

Ellis, B.G. 1976. Department of Crop and Soil Sciences, Michigan State

University, East Lansing, Michigan. Personnal communication on March 25, 1976.

Frere, M.H. 1975. Integrating Chemical Factors with Water and Sediment Transport from a Watershed. J. Envir. Qual. 4(1):12-17

Hagin, J., and A. Amberger. 1974. Contribution of Fertilizers and Manures to the N- and P- Load of Waters. A Computer Simulation. Report Submitted to Deutsche Forschungs Gemeinschaft. 123 p.

Hubbard, R.K. 1975. The Vertical and Horizontal Redistribution of Nitrogen, Chloride, and Phosphorus by Precipitation and Surface Runoff on Two Similar Watersheds. M.S. Thesis, Michigan State University, E. Lansing, Michigan. 113 pp.

Hydrocomp, Inc. 1976. Hydrocomp Simulation Programming: Operations Manual. Palo Alto, California, 2nd ed.

Johanson, R.C., and N.H. Crawford. 1976. Development of the Watershed Erosion and Sediment Transport Model. Prepared for the Environmental Research Laboratory, Athens, Georgia. Research Grant No. R803726-01-0.

Mehran, M., and K.K. Tanji. 1974. Computer Modeling of Nitrogen Transformations in Soils. J. Environ. Qual. 3(4):291-395.

Misra, C., D.R. Nielson, and J.W. Biggar. 1974. Nitrogen Transformations in Soil During Leaching; II Steady State Nitrification and Nitrate Reduction. Soil Sci. Soc. Amer. Proc. 38:294-299.

Rao, P.S.C., H.M. Selim, J.M. Davidson, and D.A. Greatz. 1976a. Simulation of Transformations and Transport of Selected Nitrogen Species in Soils Proc. Soil and Crop Sci. Soc. Florida. 35:

Rao, P.S.C., J.M. Davidson, and L.C. Hammond. 1976b. Estimation of Nonreactive and Reactive Solute Front Locations in Soils. In: Residual Management by Land Disposal. Proceedings of the Hazardous Waste Research Symposium, Tucson, Arizona. EPA-600/9-76-015. pp. 235-242.

Selim, H.M. 1976. Soil Science Department. University of Florida, Gainesville, Florida. Personnal communication on November 3-4, 1976.

Smith, C.N., R.A. Leonard, G.W. Langdale, and G.W. Bailey. 1977. Transport of Agricultural Chemicals from Small Upland Piedmont Watersheds. U.S. Environmental Protection Agency, Athens, Georgia and U.S. Department of Agriculture, Watkinsville, Georgia. Final report on Agreement No. D6-0381. (In Preparation.)

Stanford, G., and S.J. Smith. 1972. Nitrogen Mineralization Potential in Soil. Soil Sci. Soc. Amer. Proc. 36:465-472.

Starr, J.L., F.E. Broadbent, and D.R. Nielsen. 1974. Nitrogen

Transformations During Continuous Leaching. Soil Sci. Soc. Amer. Proc. 38:283-289.

Van den Honert, T.H., and J.J.M. Hooymons. 1955. On the Absorption by Maize in Water Culture. Acta Bot Neerlandica 43:376-384.

Viets, Franck G. 1965. The Plant's Need for and Use of Nitrogen. In: Soil Nitrogen, W.V. Bartholomew and F.E. Clark (eds.), Madison, Wis., Am. Soc. Agron. Agronomy Monograph No. 10. p. 503-549.

Wierenga, P.J., and C.T. DeWit. 1970. Simulation of Heat Transfer in Soils. Soil Sci. Soc. Amer. Proc. 34(6):845-848.

APPENDIX A

ARM MODEL INPUT DESCRIPTION: VERSION DATED 06/10/77

TABLE A1. ARM MODEL INPUT PARAMETER DESCRIPTION

TYPE	NAME	DESCRIPTION
Control	HYCAL	Specifies type of information desired PROD-production run, prints full tables for each interval as specified by PRINT CALB-calibration run, prints removal values for each interval as specified by PRINT
	INPUT	Input units, ENGL-english, METR-metric
	OUTPUT	Output units, ENGL-english, METR-metric, BOTH-both
	PRINT	Denotes the interval of printed output, INTR-each interval, HOUR-each hour, DAYS-each day, MNTH-each month
	SNOW	NO-snowmelt not performed, YES,snowmelt calculations performed
	PEST	NO-pesticides not performed, YES-pesticide calculations performed
	NUTR	NO-nutrients not performed, YES-nutrients calculations performed
	ICHECK	ON-checks most of the hydrology, snow (if used), sediment, and pesticide (if used) input parameter values and prints out error and warning statements for input parameter values that are outside of acceptable value limits, OFF-no check is made
	DISK	NO-no output written to disk YES-LSRO and/or EROS written to disk
	IDEBUG	OFF-no output to check values written to disk ON-print echo of output written to disk
	CHAR	RUNOFF-Lands Surface RunOff (LSRO) output SEDIMENT-EROSion (EROS) from sediment output OVERLAND-Runoff fRom Overland Surface (RROS) output
	TITLE	Title for data set on disk (80 char)
	DSNFLO	Data set number for LSRO file
	DSNERS	Data set number for EROS file
	DSNROS	Data set number for RROS file
	INTRVL	Time interval of operation (5, 15, or 60 minutes)
	HYMIN	Minimum flow for printed output during a time interval
	AREA	Watershed area
	BGNDAY BGNMON BGNYR	Date simulation begins-day, month, year
	ENDDAY ENDMON ENDYR	Date simulation ends-day, month, year

(continued)

TABLE A1 (continued)

TYPE	NAME	DESCRIPTION
Hydrology	UZSN	Nominal upper zone soil moisture storage
	UZS	Initial upper zone soil moisture storage
	LZSN	Nominal lower zone soil moisture storage
	LZS	Initial lower zone soil moisture storage
	L	Length of overland flow to channel
	SS	Average overland flow slope
	NN	Manning's n for overland flow
	A	Fraction of area that is impervious
	EPXM	Maximum interception storage
	PETMUL	Potential evapotranspiration data correction factor
	K3	Index to actual evaporation on a monthly basis (12 values)
	INFIL	Mean infiltration rate
	INTER	Interflow parameter, alters runoff timing
	IRC	Interflow recession rate
	K24L	Fraction of groundwater recharge percolating to deep groundwater
	KK24	Groundwater recession rate
	K24EL	Fraction of watershed area where groundwater is within reach of vegetation
	SGW	Initial groundwater storage
	GWS	Initial groundwater slope
	KV	Parameter to allow variable recession rate for groundwater discharge
	ICS	Initial interception storage
	OFS	Initial overland flow storage
	IFS	Initial interflow storage
Snow	SNOWPRINT	NO-hourly snow tables not printed during snow pack periods YES-hourly snow tables printed
	RADCON	Correction factor for radiation melt
	CCFAC	Correction factor for condensation and convection melt
	SCF	Snow correction factor for raingage catch deficiency
	ELDIF	Elevation difference from temperature station to mean watershed elevation
	IDNS	Initial density of new snow
	F	Fraction of watershed with complete forest cover
	DGM	Daily groundmelt
	WC	Water content of snowpack by weight
	MPACK	Water equivalent of snowpack for complete watershed coverage
	EVAPSN	Correction factor for snow evaporation
	MELEV	Mean elevation of watershed
	TSNOW	Temperature below which precipitation becomes snow

(continued)

TABLE A1 (continued)

TYPE	NAME	DESCRIPTION
	PACK	Initial water equivalent of snowpack
	DEPTH	Initial depth of snowpack
	PETMIN	Minimum temperature at which PET occurs
	PETMAX	Temperature at which PET is reduced by 50 percent
	WMUL	Wind data correction factor
	RMUL	Radiation data correction factor
	KUGI	Index to forest density and undergrowth
Sediment	COVPMO	Fraction of crop cover on a monthly basis (12 values)
	TIMTIL	Time when soil is tilled (Julian day, i.e. day of the year, e.g. January 1 = 1, December 31 = 365/366) (12 dates)
	YRTIL	Corresponding year (last two digits only) for TIMTIL (12 values)
	SRERTL	Fine deposits produced by tillage corresponding to TIMTIL and YRTIL (12 values)
	JRER	Exponent of rainfall intensity in soil splash equation
	KRER	Coefficient in soil splash equation
	JSER	Exponent of overland flow in sediment washoff equation
	KSER	Coefficient in sediment washoff equation
	SRERI	Initial fines deposit
	SCMPAC	Rate by which soil fines are decreased per day on non-rain days
Pesticide	PESTICIDE	Title word to begin the reading of pesticide input parameters
	APMODE	Application mode, SURF-surface applied, SOIL-soil incorporated
	DESORP	NO-single-valued adsorption/desorption used, YES-non-single-valued adsorption/desorption algorithm used
	PSSZ	Initial pesticide storage in surface zone
	PSUZ	Initial pesticide storage in upper zone
	PSLZ	Initial pesticide storage in lower zone
	PSGZ	Initial pesticide storage in groundwater zone
	TIMAP	Time of pesticide application (Julian day) (12 values)
	YEARAP	Year of pesticide application (last two digits only) (12 values)
	SSTR	Pesticide application for entire watershed (12 values)
	CMAX	Maximum solubility of pesticide in water
	DD	Permanent fixed adsorption capacity
	K	Coefficient in Freundlich adsorption equation
	N	Exponent in Freundlich adsorption equation
	NP	Exponent in Freundlich desorption equation
	DDG	Julian day when KDG(1) begins (max. of 12 values)
	YDG	Corresponding year in which DDG applies
	KDG	Pesticide decay rate (per day) (max. 12 values)

(continued)

TABLE A1 (continued)

TYPE	NAME	DESCRIPTION
Soil	LZTEMP	Lower zone temperature on a monthly basis (12 values)
	ASZT	Slope of surface zone soil temperature regression equation
	BSZT	Surface zone soil temperature regression equation
	AUZT	Slope of upper zone soil temperature regression equation
	BUZT	Upper zone soil temperature regression equation
	SZDPTH	Surface layer soil depth
	UZDPTH	Upper zone depth or depth of soil incorporation
	BDSZ	Bulk density of surface zone soil
	BDUZ	Bulk density of upper zone soil
	BDLZ	Bulk density of lower zone soil
	UZF	Upper zone chemical percolation factor
	LZF	Lower zone chemical percolation factor
Nutrient		
	TSTEP	Timestep of chemical and biological transformations, must be an integer number of time steps in a day, and an integer number of simulation intervals (INTRVL) in a TSTEP, range of TSTEP is 5 or 15 minutes to 1440 minutes, but the solution technique works best at 60 minutes or less.
	NAPPL	Number of fertilizer applications, values may range from 0 to 5
	TIMHAR	Time of plant harvesting, Julian day of the year, value may range from 0 to 366
	ULUPTK	Fraction of maximum crop uptake of nutrients for the the upper layers (surface and upper zone) on a monthly basis (12 values), should be 1.0 or less
	LZUPTK	Fraction of maximum crop uptake of nutrients for the lower zone on a monthly basis (12 values), should be 1.0 or less
Nitrogen Reaction Rates		
	K1	Oxidation rate of solution ammonium
	KD	Reduction rate of nitrite and nitrate to gaseous nitrogen
	KPL	Uptake rate of nitrate by plants
	KAM	Ammonification or mineralization rate of ORG-N to ammonium
	KIM	Immobilization rate of solution ammonium to ORG-N
	KKIM	Immobilization rate of nitrate (and nitrite) to ORG-N
	KSA	Transfer rate of ammonium from solution to adsorbed (adsorption)
	KAS	Transfer rate of ammonium from adsorbed to solution (desorption)

(continued)

TABLE A1 (continued)

TYPE	NAME	DESCRIPTION
Phosphorus Reaction Rates		
	KM	Mineralization rate of ORG-P to solution phospate
	KIM	Immobilization rate of solution phosphate to ORG-P
	KPL	Uptake rate of phosphate in solution
	KSA	Transfer rate of phosphate from solution to adsorbed form
	KAS	Transfer rate of phosphate from adsorbed to solution form
Nitrogen Storages		
	ORG-N	Organic nitrogen in or attached to soil
	NH4-S	Ammonium in solution
	NH4-A	Ammonium adsorbed to soil
	NO2+NO3	Nitrite and nitrate
	N2	Gaseous nitrogen forms from denitrification
	PLNT-N	Plant nitrogen
Phosphorus Storages		
	ORG-P	Organic phosphorus in or attached to soil
	PO4-S	Phosphate in solution
	PO4-A	Phosphate adsorbed to soil
	PLNT-P	Plant phosphorus
Chloride Storage		
	CL	Chloride

TABLE A2. ARM MODEL INPUT SEQUENCE AND PARAMETER ATTRIBUTES
(excluding Nutrient input and parameters)

Namelist Name	Parameter Name	Type	English Units	Metric Units
	Watershed name (up to 72 characters)			
	Chemical name and/or run information (up to 80 characters)			
	HYCAL	character		
	INPUT	character		
	OUTPUT	character		
	PRINT	character		
	SNOW	character		
	PEST	character		
	NUTR	character		
	ICHECK	character		
	DISK	character		
	IDEBUG	character		
	CHAR	character		
	TITLE	(up to 80 characters)		
	DSNFLO	integer		
	DSNERO	integer		
	DSNROS	integer		
CNTL	INTRVL	integer	minutes	minutes
	HYMIN	real	cubic feet/sec	cubic meters/sec
	AREA	real	acres	hectares
STRT	BGNDAY	integer		
	BGNMON	integer		
	BGNYR	integer		
ENDD	ENDDAY	integer		
	ENDMON	integer		
	ENDYR	integer		
LND1	UZSN	real	inches	millimeters
	UZS	real	inches	millimeters
	LZSN	real	inches	millimeters
	LZS	real	inches	millimeters
LND2	L	real	feet	meters
	SS	real		
	NN	real		
	A	real		
	EPXM	real	inches	millimeters
	PETMUL	real		
LND3	K3	real		

(continued)

TABLE A2 (continued)

Namelist Name	Parameter Name	Type	English Units	Metric Units
LND4	INFIL	real	inches/hour	millimeters/hour
	INTER	real		
	IRC	real		
	K24L	real		
	KK24	real		
	K24EL	real		
LIND5	SGW	real	inches	millimeters
	GWS	real		
	KV	real		
	ICS	real	inches	millimeters
	OFS	real	inches	millimeters
	IFS	real	inches	millimeters
	SNOWPRINT	character		
SNO1	RADCON	real		
	CCFAC	real		
	SCF	real		
	ELDIF	real	1000 feet	kilometers
	IDNS	real		
	F	real		
SNO2	DGM	real	inches/day	millimeters/day
	WC	real		
	MPACK	real	inches	millimeters
	EVAPSN	real		
	MELEV	real	feet	meters
	TSNOW	real	degrees F	degrees C
SNO3	PACK	real	inches	millimeters
	DEPTH	real	inches	millimeters
SNO4	PETMIN	real	degrees F	degrees C
	PETMAX	real	degrees F	degrees C
	WMUL	real		
	RMUL	real		
	KUGI	integer		
CROP	COVPMO	real		
MUD1	TIMTIL	integer	days	days
MUD2	YRTIL	integer	year	year
MUD3	SRERTL	real	tons/acre	tonnes/hectare

(continued)

TABLE A2 (continued)

Namelist Name	Parameter Name	Type	English Units	Metric Units
SMDL	JRER	real		
	KRER	real		
	JSER	real		
	KSER	real		
	SRERI	real	tons/acre	tonnes/hectare
	SCMPAC	real		
	PESTICIDE	character		
	APMODE	character		
	DESORP	character		
PSTR	PSSZ	real	pounds/acre	kilograms/hectare
	PSUZ	real	pounds/acre	kilograms/hectare
	PSLZ	real	pounds/acre	kilograms/hectare
	PSGZ	real	pounds/acre	kilograms/hectare
PST1	TIMAP	integer	day	day
PST2	YEARAP	integer	year	year
PST3	SSTR	real	pounds/acre	kilograms/hectare
AMDL	CMAX	real	pounds/pound	kilograms/kg
	DD	real	lbs. pesticide/ lbs. soil	kgs. pesticide/ kgs. soil
	K	real		
	N	real		
	NP	real		
DEGD	DDG	integer	day	day
DEGY	YDG	integer	year	year
DEGR	KDG	real	per day	per day
LZTP	LZTEMP	real	degrees F	degrees C
RETP	ASZT	real		
	BSZT	real		
	AUZT	real		
	BUZT	real		
DPTH	SZDPTH	real	inches	millimeters
	UZDPTH	real	inches	millimeters
	BSDZ	real	pounds/cubic ft	grams/cubic cm
	BDUZ	real	pounds/cubic ft	grams/cubic cm
	BDLZ	real	pounds/cubic ft	grams/cubic cm
	UZF	real		
	LZF	real		

TABLE A1. ARM MODEL NUTRIENT PARAMETER INPUT SEQUENCE AND ATTRIBUTES

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
NUTRIENT			Character	1-8			Name to indicate start of nutrient input sequence.
	&NUTRIN		Character	2-8			Namelist name of nutrient control information.
		TSTEP	Integer	Any	minutes	minutes	Length of timestep for chemical and biological transformations. There must be an even number of time steps in a day, and an even number of simulation intervals in a TSTEP. Range = 5 or 15 to 1440.
		NAPPL	Integer	Any			Number of nutrient applications over a year of simulation. Values may range from 0 to 5.
		TIMHAR	Integer	Any	day	day	Time of plant harvesting, Julian day of the year. Value may range from 0 to 366.
		&END	Character	Any			Indicate end of namelist input of nutrient control information.
	&PLANTU		Character	2-8			Namelist name for upper layers plant uptake informations.
		ULUPTK	Real	Any			12 values of fraction of maximum monthly crop uptake of nutrients, should be 1.0 or less.
	&PLANTL		Character	2-8			Namelist name for lower zone plant uptake information.
		LZUPTK	Real	Any			12 values of fraction of maximum monthly crop uptake should be 1.0 or less.
REACTION RATES			Character	1-14			Name to indicate start of nutrient input sequence.
	NITROGEN		Character	1-8			Indicates nitrogen reaction rate will follow.
	SURFACE		Character	1-7			Surface layer reaction rates follow.
		K1	Real	1-8	per day	per day	Oxidation rate of solution ammonium to nitrite and nitrate.
		KD	Real	9-16	per day	per day	Reduction rate of nitrite and nitrate to gaseous nitrogen.
		KPL	Real	17-24	per day	per day	Uptake of nitrate by plants.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		KAM	Real	25-32	per day	per day	Ammonification or mineralization rate of organic-N to ammonium.
		KIM	Real	33-40	per day	per day	Immobilization rate of solution ammonium to organic-N.
		KKIM	Real	41-48	per day	per day	Immobilization rate of nitrate and nitrite to organic-N.
		KSA	Real	49-56	per day	per day	Transfer rate of ammonium from solution to adsorbed (adsorption).
		KAS	Real	57-64	per day	per day	Transfer rate of ammonium from adsorbed to solution (desorption).
	UPPER ZONE		Character	1-10			Upper zone reaction rates follow.
		KI	Real	1-8	per day	per day	Oxidation rate of solution ammonium to nitrite and nitrate.
		KD	Real	9-16	per day	per day	Reduction rate of nitrite and nitrate to gaseous nitrogen.
		KPL	Real	17-24	per day	per day	Uptake of nitrate by plants.
		KAM	Real	25-32	per day	per day	Ammonification or mineralization rate of organic-N to ammonium.
		KIM	Real	33-40	per day	per day	Immobilization rate of solution ammonium to organic-N.
		KKIM	Real	41-48	per day	per day	Immobilization rate of nitrate and nitrite to organic-N.
		KSA	Real	49-56	per day	per day	Transfer rate of ammonium from solution to adsorbed (adsorption).
		KAS	Real	57-64	per day	per day	Transfer rate of ammonium from adsorbed to solution (desorption).
	LOWER ZONE		Character	1-10			Lower zone reaction rates folow.
		KI	Real	1-8	per day	per day	Oxidation rate of solution ammonium to nitrite and nitrate.
		KD	Real	9-16	per day	per day	Reduction rate of nitrite and nitrate to gaseous nitrogen.
		KPL	Real	17-24	per day	per day	Uptake of nitrate by plants.
		KAM	Real	25-32	per day	per day	Ammonification or mineralization rate of organic-N to ammonium.
		KIM	Real	33-40	per day	per day	Immobilization rate of dissolved ammonium to organic-N.
		KKIM	Real	41-48	per day	per day	Immobilization rate of nitrate and nitrite to organic-N.
		KSA	Real	49-56	per day	per day	Transfer rate of ammonium from solution to adsorbed (adsorption).

(continued)

Reproduced from
best available copy.

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		KAS	Real	57-64	per day	per day	Transfer rate of ammonium from adsorbed to solution (desorption).
	GROUNDWATER		Character	1-11			Groundwater reaction rates follow.
		K1	Real	1-8	per day	per day	Oxidation rate of solution ammonium to nitrite and nitrate.
		KD	Real	9-16	per day	per day	Reduction rate of nitrite and nitrate to gaseous nitrogen.
		KPL	Real	17-24	per day	per day	Uptake of nitrate by plants.
		KAM	Real	25-32	per day	per day	Ammonification or mineraliza-tion rate of organic-N to ammonium.
		KIM	Real	33-40	per day	per day	Immobilization rate of solution ammonium to organic-N.
		KKIM	Real	41-48	per day	per day	Immobilization rate of nitrate and nitrite to organic-N.
		KSA	Real	49-56	per day	per day	Transfer rate of ammonium from solution to adsorbed (adsorption).
		KAS	Real	57-64	per day	per day	Transfer rate of ammonium from adsorbed to solution (desorption).
	TEMPERATURE COEFFICIENTS		Character	1-23			Temperature coefficients for reaction rates.
		THK1	Real	1-8	per day	per day	
		THKD	Real	9-16	per day	per day	
		THKPL	Real	17-24	per day	per day	
		THKAM	Real	25-32	per day	per day	Temperature coefficients for corresponding nitrogen reactions, should be greater than or equal to 1.0.
		THKIM	Real	33-40	per day	per day	
		THKKIM	Real	41-48	per day	per day	
		THKSA	Real	49-56	per day	per day	
		THKAS	Real	57-64	per day	per day	
PHOSPHORUS			Character	1-10			Indicates phosphorus reaction rates will follow.
	SURFACE		Character	1-7			Surface layer reaction rates.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		KM	Real	1-8	per day	per day	Mineralization rate of Organic-P to solution phosphate
		KIM	Real	9-16	per day	per day	Immobilization rate of solution phosphate to Organic-P.
		KPL	Real	17-24	per day	per day	Uptake of phosphate in solution. by plants.
		KSA	Real	25-32	per day	per day	Transfer rate of phosphate from solution to adsorbed.
		KAS	Real	33-40	per day	per day	Transfer rate of phosphate from adsorbed to solution.
	UPPER ZONE		Character	1-10			Upper zone reaction rates follow.
		KM	Real	1-8	per day	per day	Mineralization rate of Organic-P to solution phosphate.
		KIM	Real	9-16	per day	per day	Immobilization rate of solution phosphate to Organic-P.
		KPL	Real	17-24	per day	per day	Uptake of phosphate in solution. by plants.
		KSA	Real	25-32	per day	per day	Transfer rate of phosphate from solution to adsorbed.
		KAS	Real	33-40	per day	per day	Transfer rate of phosphate from adsorbed to solution.
	LOWER ZONE		Character	1-10			Lower zone reaction rates follow.
		KM	Real	1-8	per day	per day	Mineralization rate of Organic-P to solution phosphate.
		KIM	Real	9-16	per day	per day	Immobilization rate of dissolved PO4-P to Organic-P.
		KPL	Real	17-24	per day	per day	Uptake of phosphate in solution by plants.
		KSA	Real	25-32	per day	per day	Transfer rate of phosphate from solution to adsorbed.
		KAS	Real	33-40	per day	per day	Transfer rate of phosphate from adsorbed to solution.
	GROUNDWATER		Character	1-11			Lower zone reaction rates follow.
		KM	Real	1-8	per day	per day	Mineralization rate of Organic-P to solution phosphate.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		KIM	Real	9-16	per day	per day	Immobilization rate of solution phosphate to Organic-P.
		KPL	Real	17-24	per day	per day	Uptake of phosphate in solution by plants
		KSA	Real	25-32	per day	per day	Transfer rate of phosphate from solution to adsorbed.
		KAS	Real	33-40	per day	per day	Transfer rate of phosphate from adsorbed to solution.
	TEMPERATURE COEFFICIENTS		Character	1-23			Temperature coefficients for reaction rates.
		THKM	Real	1-8	per day	per day	
		THKIM	Real	9-16	per day	per day	Temperature coefficients for phosphorus reactions, should be greater than or equal to 1.0.
		THKPL	Real	17-24	per day	per day	
		THKSA	Real	25-32	per day	per day	
		THKAS	Real	33-40	per day	per day	
END			Character	1-3			'END' terminates input of rates. Nitrogen and phosphorus rates are optional, program defaults them to 0.0 if not specified.
INITIAL			Character	1-7			Initialization of soil constituents follows.
	NITROGEN		Character	1-8			Initial nitrogen forms follow.
	SURFACE		Character	1-7			Surface layer initialization follows.
		NBLK	Integer	16			Number of blocks which will be input. 0 or 1 indicate the average concentration over the surface layer in input on one line, and NBLK=5 means five lines of input follow, one line per block. Only 0,1,5 allowed. A blank in col. 16 is read as 0.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		ORG-N	Real	1-8	lb/ac	kg/ha	Potentially mineralizable or total organic nitrogen.
		NH4-S	Real	9-16	lb/ac	kg/ha	Ammonium in solution
		NH4-A	Real	17-24	lb/ac	kg/ha	Ammonium adsorbed to soil.
		NO2 + NO3	Real	25-32	lb/ac	kg/ha	Nitrite and nitrate
		N2	Real	33-40	lb/ac	kg/ha	Gaseous nitrogen from denitrification.
		PLNT-N	Real	41-48	lb/ac	kg/ha	Plant nitrogen
	UPPER ZONE		Character	1-10			Upper zone initialization follows.
		NBLK	Integer	16			Number of blocks which will be input. 0 or 1 indicate the average concentration over the surface layer in input on one line, and NBLK=5 means five lines of input follow, one line per block. Only 0,1,5 allowed. A blank in col. 16 is read as 0.
		ORG-N	Real	1-8	lb/ac	kg/ha	Potentially mineralizable or total organic nitrogen.
		NH4-S	Real	9-16	lb/ac	kg/ha	Ammonium in solution
		NH4-A	Real	17-24	lb/ac	kg/ha	Ammonium adsorbed to soil.
		NO2 + NO3	Real	25-32	lb/ac	kg/ha	Nitrite and nitrate
		N2	Real	33-40	lb/ac	kg/ha	Gaseous nitrogen from denitrification.
		PLNT-N	Real	41-48	lb/ac	kg/ha	Plant nitrogen
	LOWER ZONE		Character	1-10			Lower zone initialization.
		ORG-N	Real	1-8	lb/ac	kg/ha	Potentially mineralizable or total organic nitrogen.
		NH4-S	Real	9-16	lb/ac	kg/ha	Ammonium in solution

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		NH4-A	Real	17-24	lb/ac	kg/ha	Ammonium adsorbed to soil.
		NO2 + NO3	Real	25-32	lb/ac	kg/ha	Nitrite and nitrate
		N2	Real	33-40	lb/ac	kg/ha	Gaseous nitrogen from denitrification.
		PLNT-N	Real	41-48	lb/ac	kg/ha	Plant nitrogen
	GROUNDWATER		Character	1-11			Groundwater zone initialization.
		ORG-N	Real	1-8	lb/ac	kg/ha	Potentially mineralizable or total organic nitrogen.
		NH3-S	Real	9-16	lb/ac	kg/ha	Ammonium in solution
		NH3-A	Real	17-24	lb/ac	kg/ha	Ammonium adsorbed to soil.
		NO2 + NO3	Real	25-32	lb/ac	kg/ha	Nitrite and nitrate.
		N2	Real	33-40	lb/ac	kg/ha	Gaseous nitrogen from denitrification.
		PLNT-N	Real	41-48	lb/ac	kg/ha	Plant nitrogen
	PHOSPHORUS		Character	1-10			Initial phosphorus forms follow.
	SURFACE		Character	1-7			Surface layer.
		NBLK	Integer	16			Number of blocks which will be input.
		ORG-P	Real	1-8	lb/ac	kg/ha	Organic phosphorus.
		PO4-S	Real	9-16	lb/ac	kg/ha	Phosphate in solution.
		PO4-A	Real	17-24	lb/ac	kg/ha	Phosphate adsorbed or combined.
		PLNT-P	Real	25-32	lb/ac	kg/ha	Plant phosphorus.
	UPPER ZONE		Character	1-10			Upper zone phosphorus initialization.
		NBLK	Integer	16			Number of blocks which will be input.
		ORG-P	Real	1-8	lb/ac	kg/ha	Organic phosphorus.

(continued)

TABLE A3 (continued)

Block	Section & Subsection	Name	Type	Column Position	Units English	Units Metric	Comments
		PO4-S	Real	9-16	lb/ac	kg/ha	Phosphate in solution.
		PO4-A	Real	17-24	lb/ac	kg/ha	Phosphate adsorbed or combined.
		PLNT-P	Real	25-32	lb/ac	kg/ha	Plant phosphorus.
	LOWER ZONE		Character	1-10			Lower zone initialization.
		ORG-P	Real	1-8	lb/ac	kg/ha	Organic phosphorus.
		PO4-S	Real	9-16	lb/ac	kg/ha	Phosphate in solution.
		PO4-A	Real	17-24	lb/ac	kg/ha	Phosphate adsorbed to soil.
		PLNT-P	Real	25-32	lb/ac	kg/ha	Plant phosphorus.
	GROUNDWATER		Character	1-11			Groundwater initialization.
		ORG-P	Real	1-6	lb/ac	kg/ha	Organic phosphorus.
		PO4-S	Real	9-16	lb/ac	kg/ha	Phosphate in solution.
		PO4-A	Real	17-24	lb/ac	kg/ha	Phosphate adsorbed or combined.

APPENDIX B

P2 WATERSHED STORM EVENT SIMULATION RESULTS

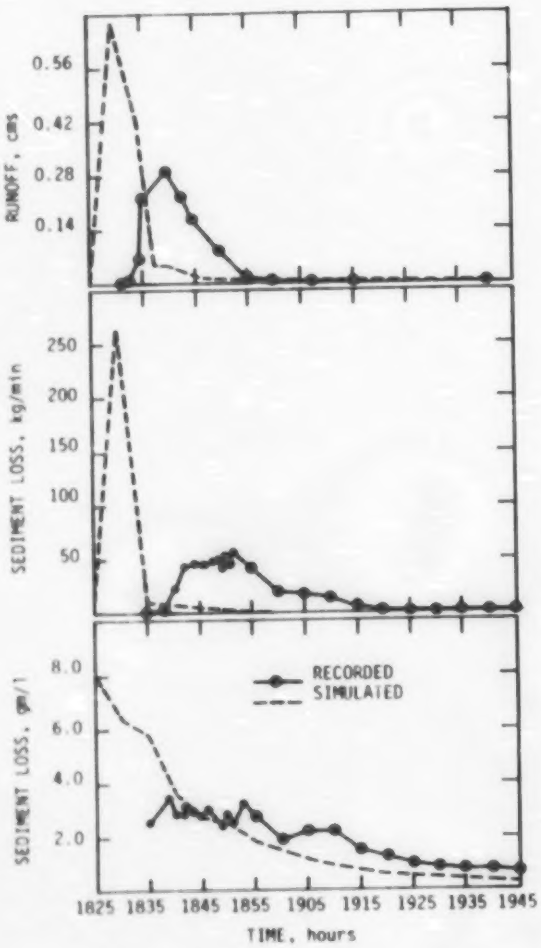


Figure B1 Runoff and sediment loss from the P2 watershed for the storm of June 27, 1974

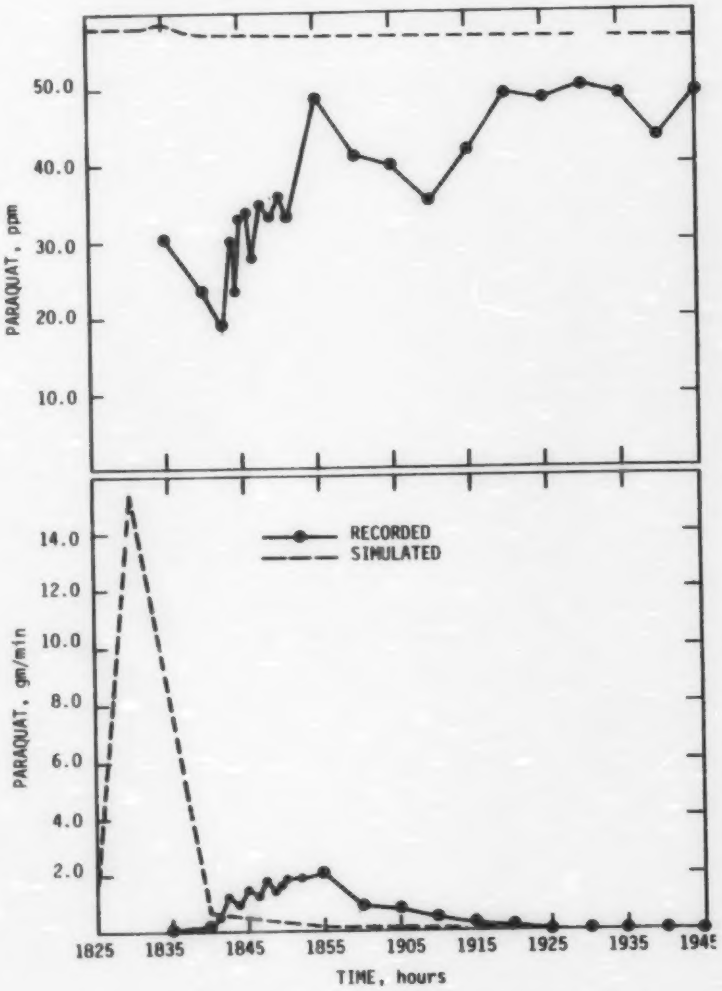


Figure B2 Paraquat removal on sediment from the P2 watershed for the storm of June 27, 1974

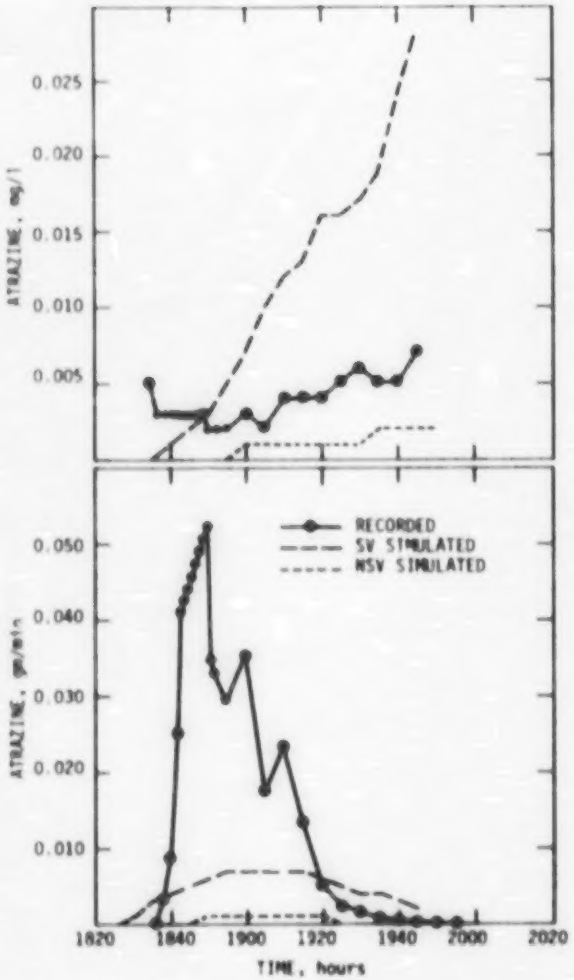


Figure B3 Atrazine removal in solution from the P2 watershed for the storm of June 27, 1974

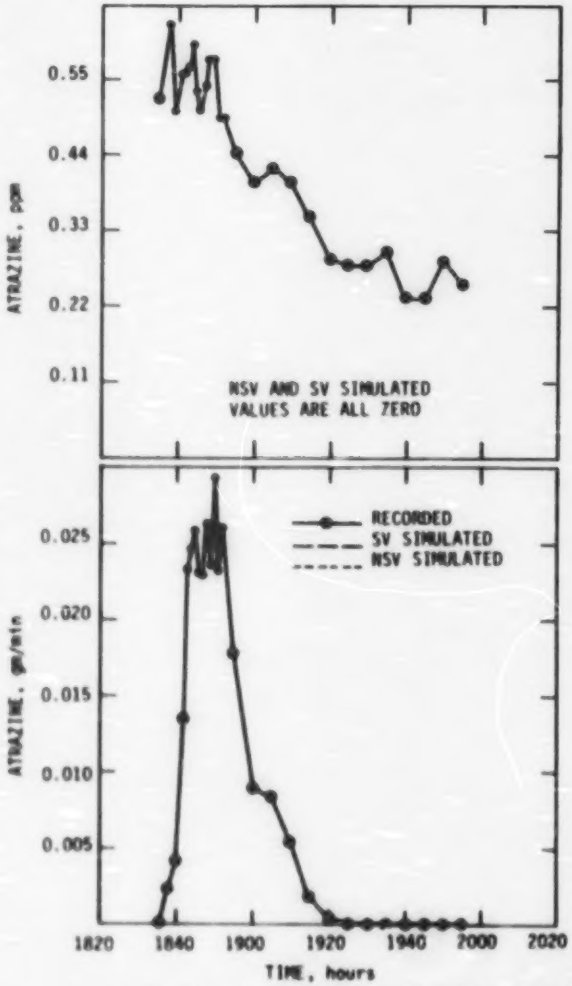


Figure B4 Atrazine removal on sediment from the P2 watershed for the storm of June 27, 1974

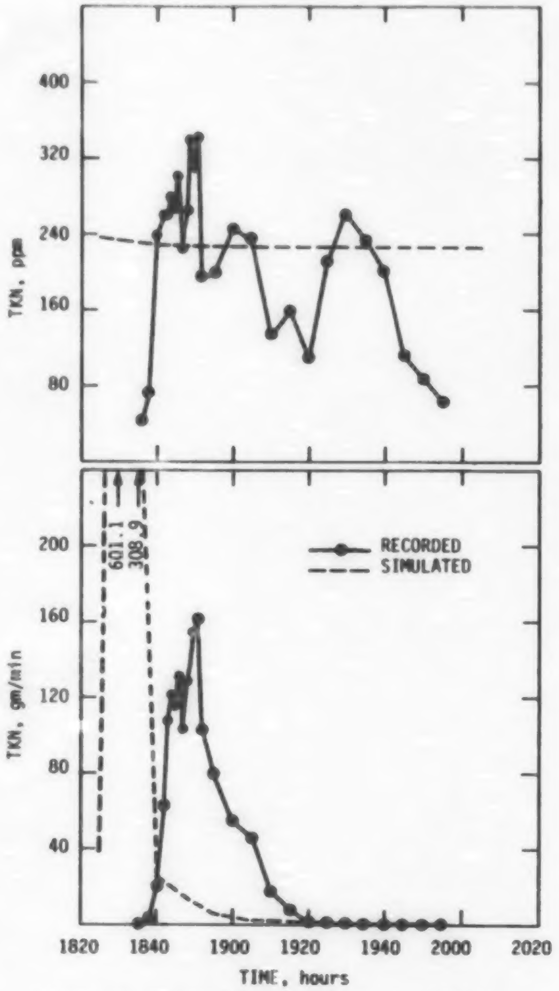


Figure B5 TKN removal on sediment from the P2 watershed for the storm of June 27, 1974

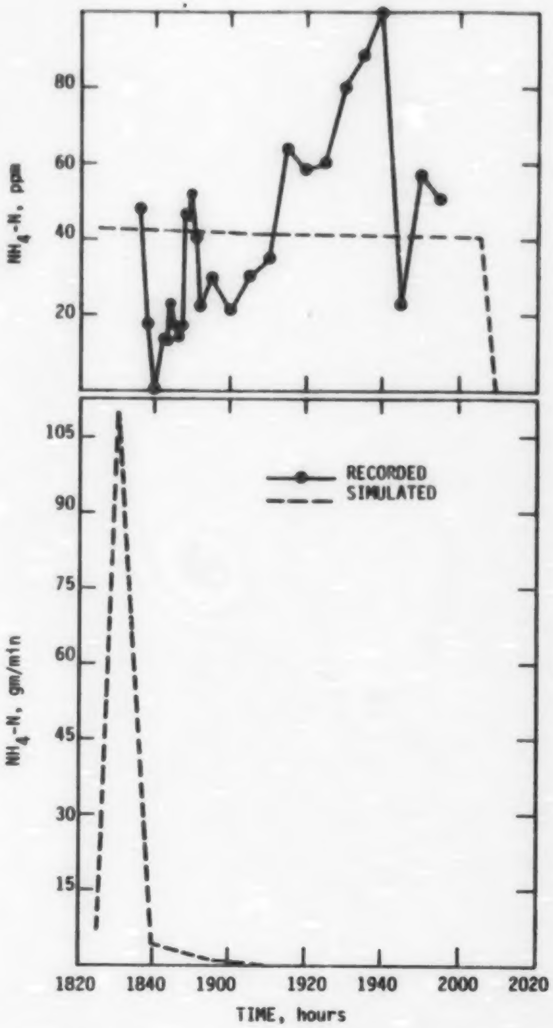


Figure B6 NH_4 removal on sediment from the P2 watershed for the storm of June 27, 1974

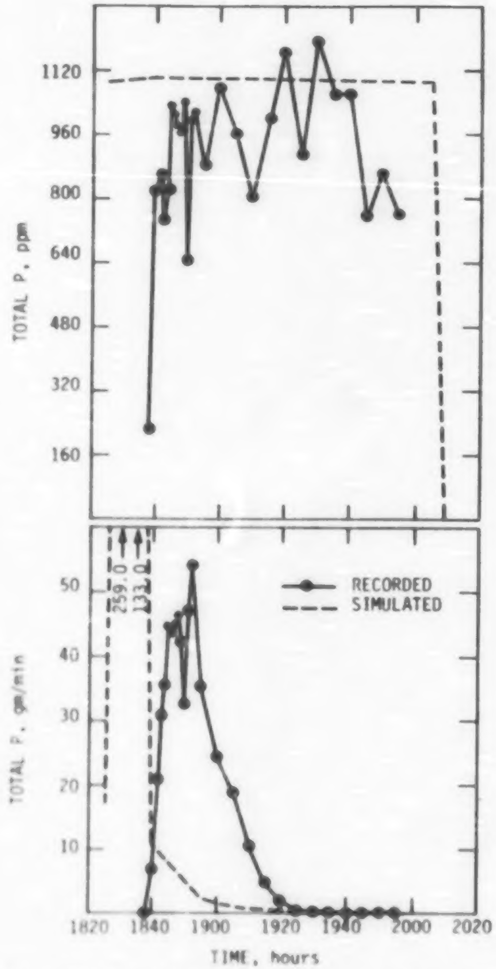


Figure B7 Total P removal on sediment from the P2 watershed for the storm of June 27, 1974

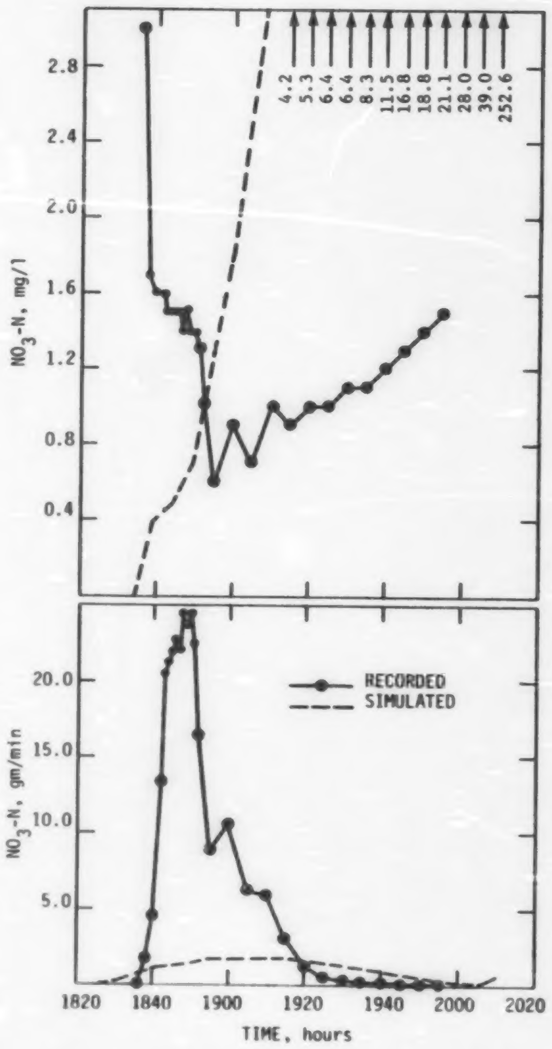


Figure B8 NO_3 removal in solution from the P2 watershed for the storm of June 27, 1974

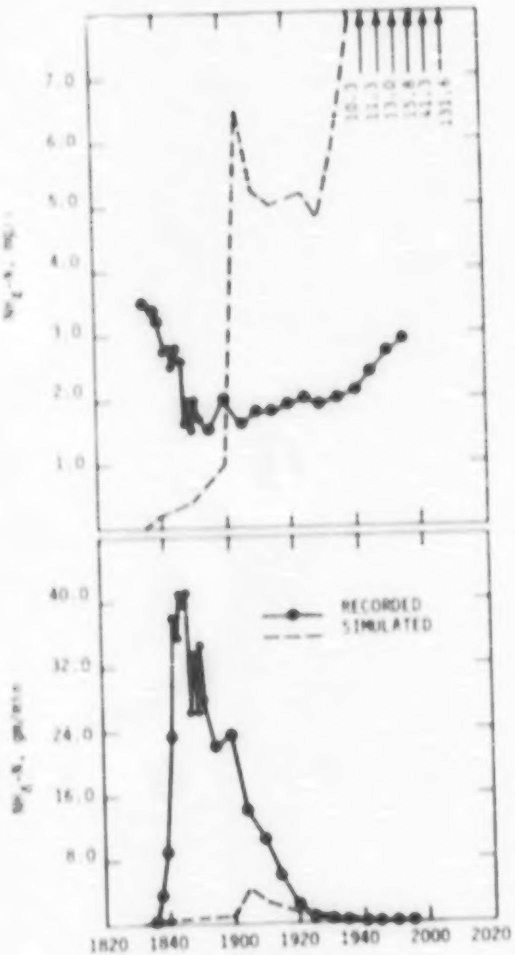


Figure B9 NH_4 removal in solution from the P2 watershed for the storm of June 27, 1974

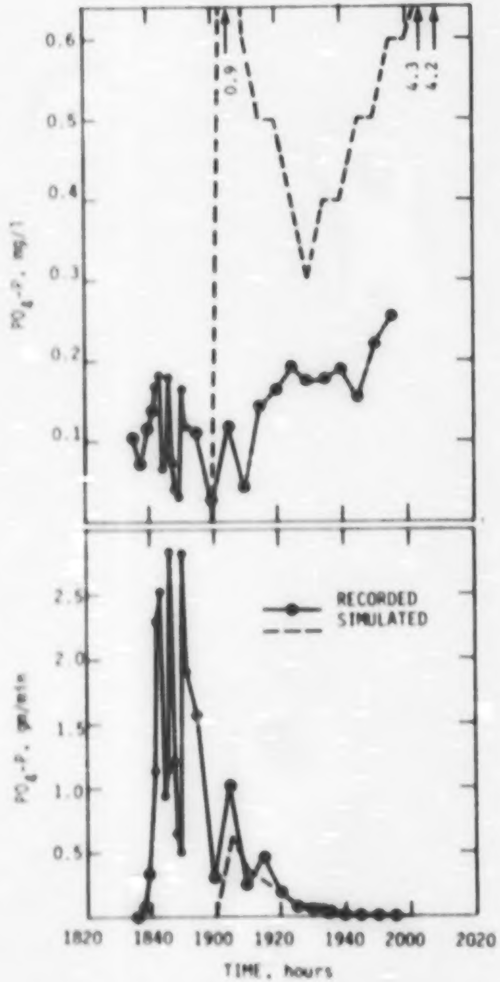


Figure B10 PO_4 removal in solution from the P2 watershed for the storm of June 27, 1974

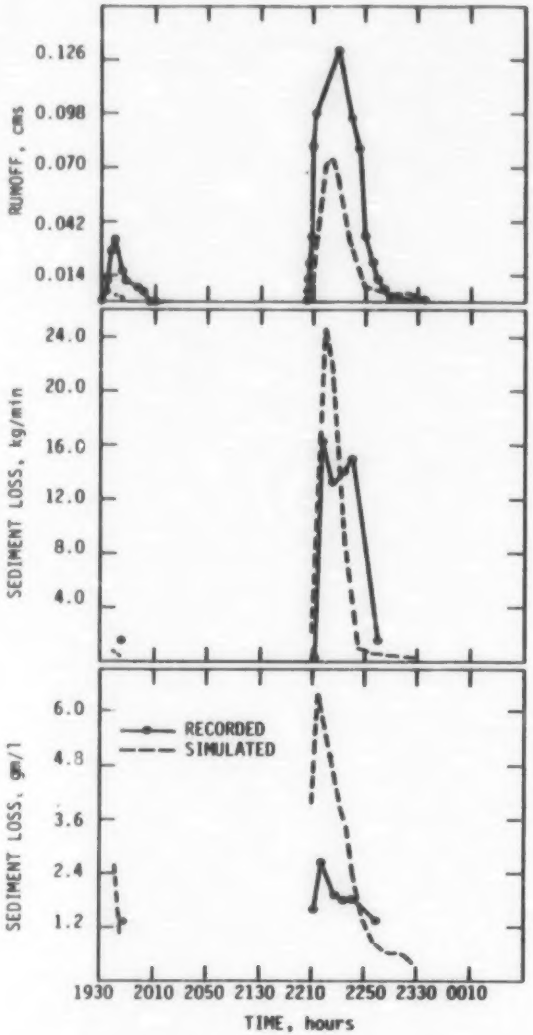


Figure B11 Runoff and sediment loss from the P2 watershed for the storm of July 24, 1975

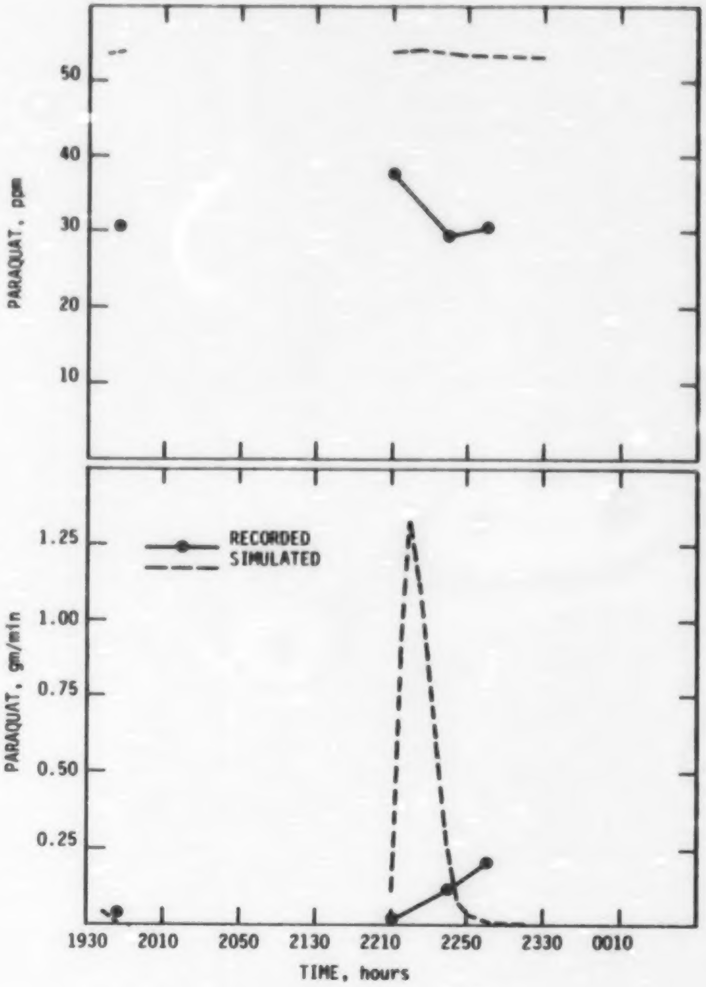


Figure B12 Paraquat removal on sediment from the P2 watershed for the storm of July 24, 1975

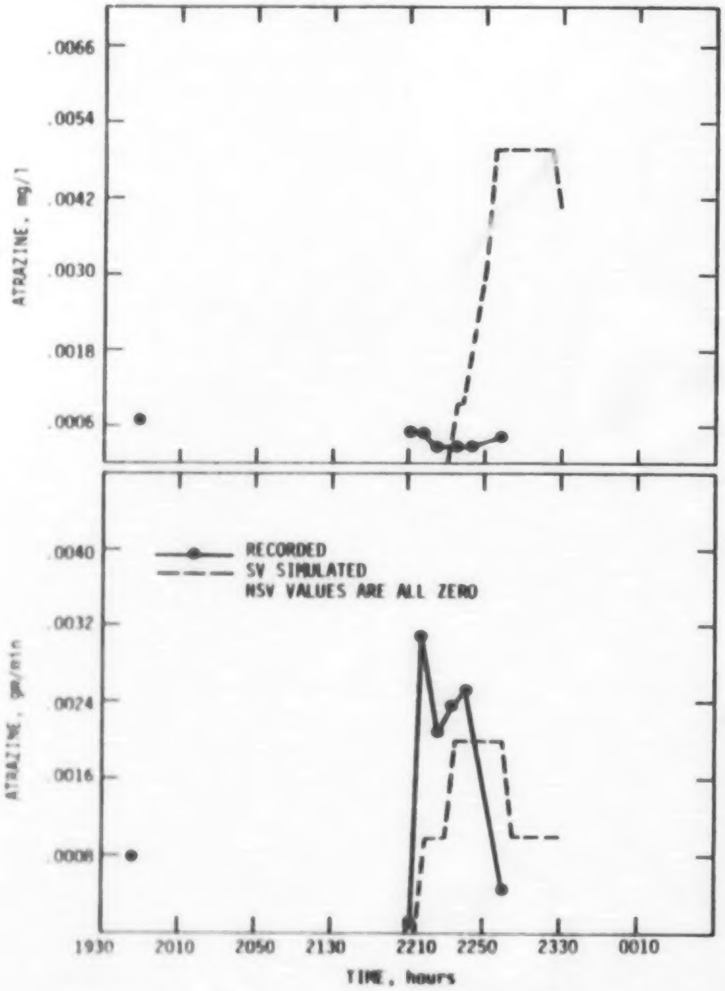


Figure B13 Atrazine removal in solution from the P2 watershed for the storm of July 24, 1975

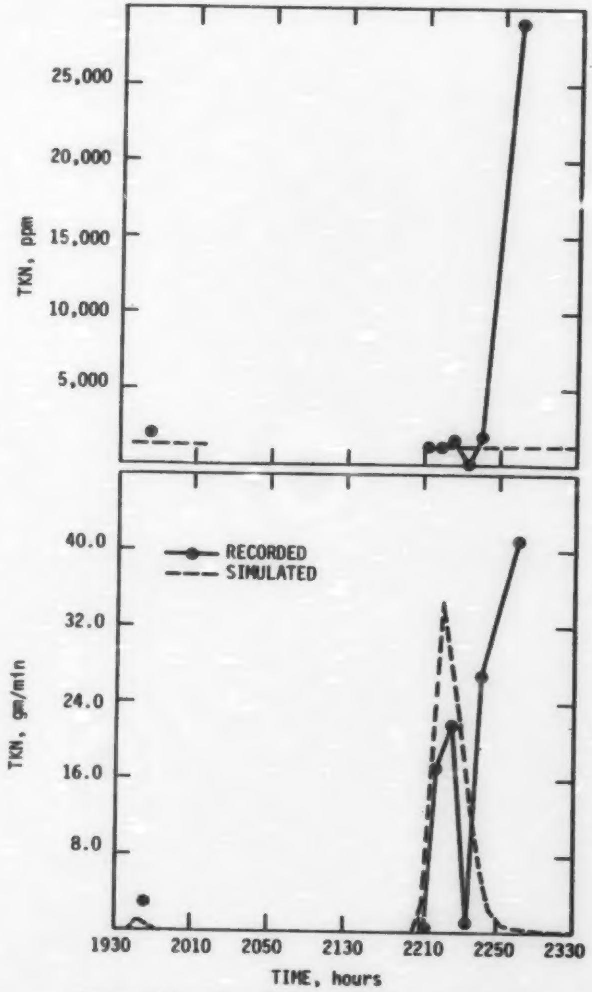


Figure B14 TKN removal on sediment from the P2 watershed for the storm of July 24, 1975

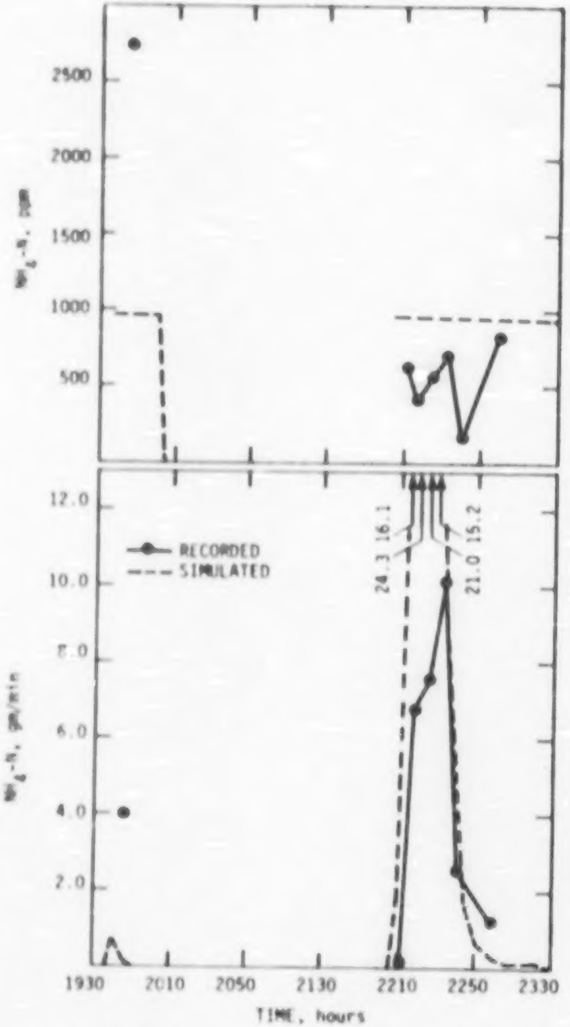


Figure B15 NH_4 removal on sediment from the P2 watershed for the storm of July 24, 1975

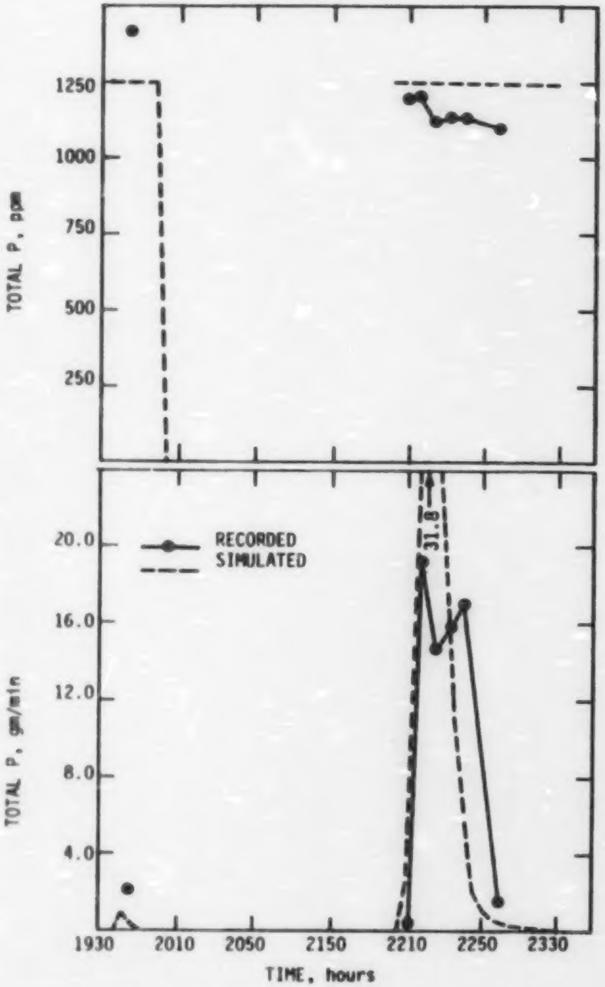


Figure B16 Total P removal on sediment from the P2 watershed for the storm of July 24, 1975

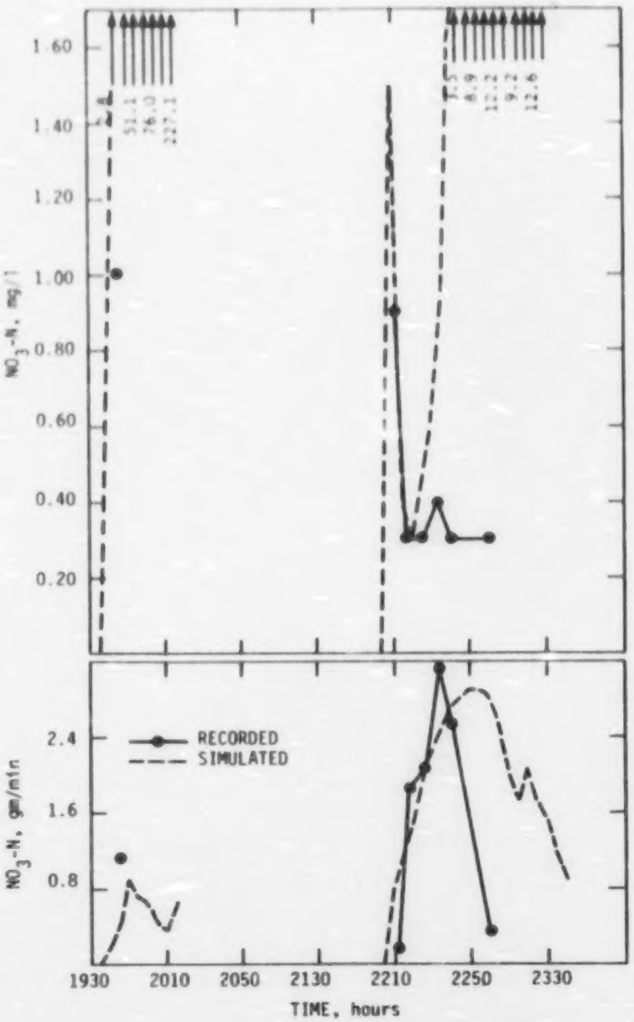


Figure B17 NO_3 removal in solution from the P2 watershed for the storm of July 24, 1975

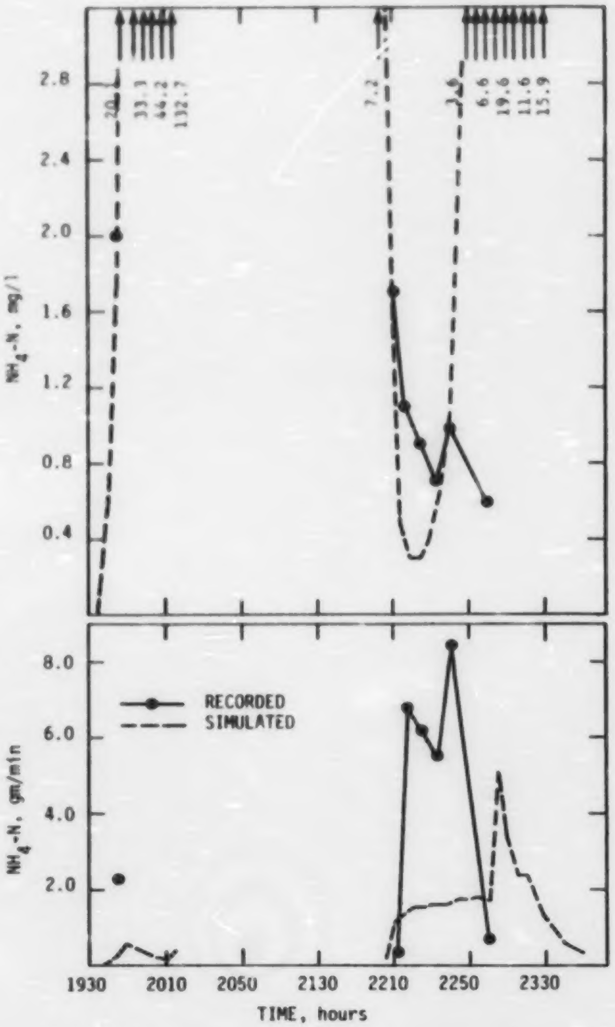


Figure B18 NH_4 removal in solution from the P2 watershed for the storm of July 24, 1975

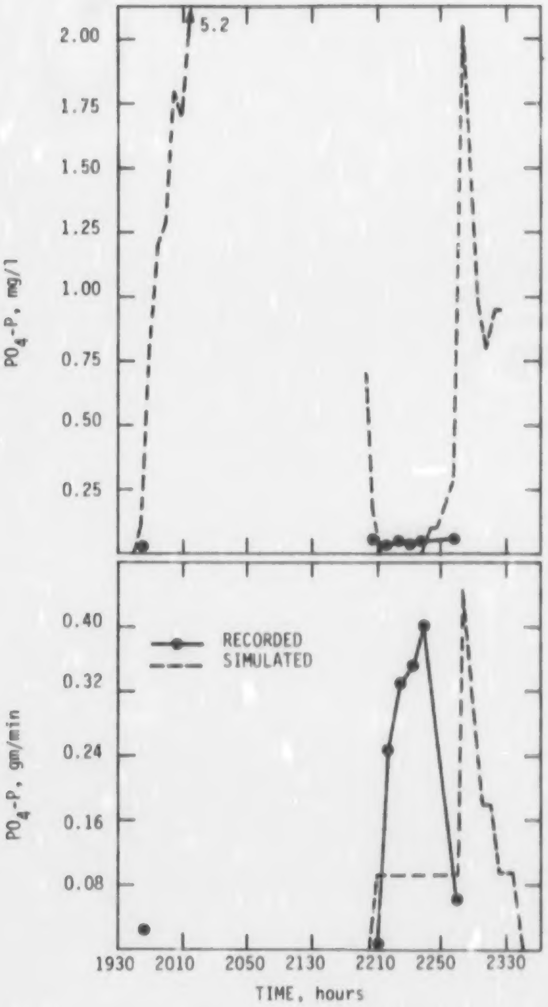


Figure B19 PO_4 removal in solution from the P2 watershed for the storm of July 24, 1975

APPENDIX C

P6 WATERSHED STORM EVENT SIMULATION RESULTS

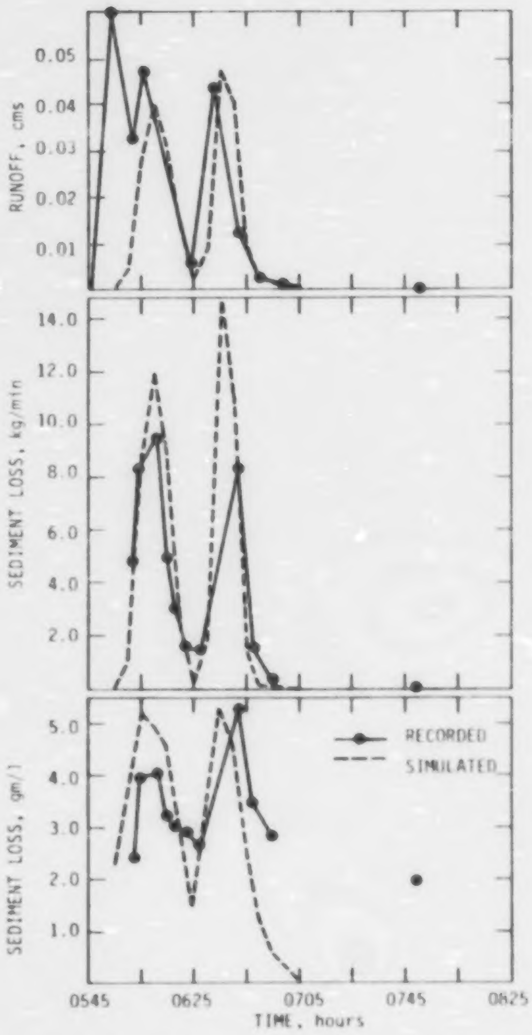


Figure C1 Runoff and sediment loss from the P6 watershed for the storm of August 27, 1974

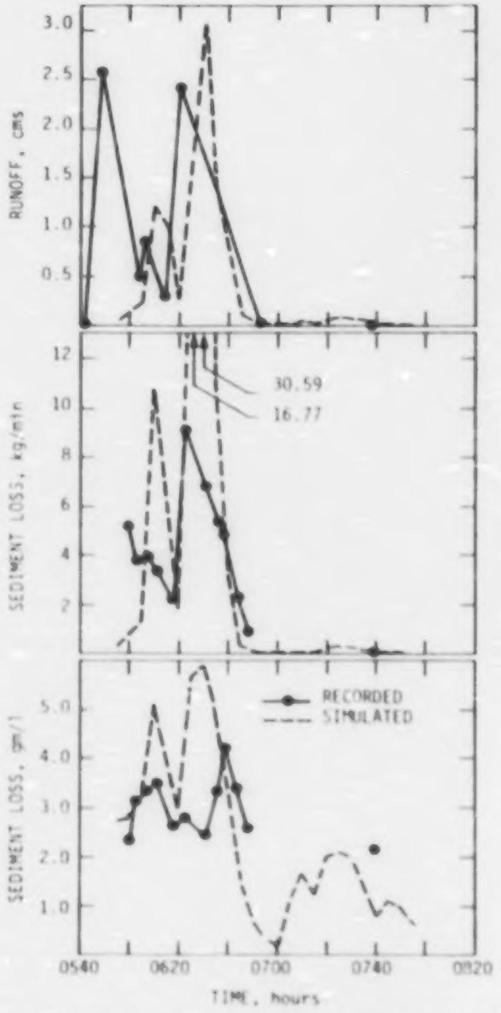


Figure C2 Runoff and sediment loss from the P6 watershed for the storm of August 13, 1974

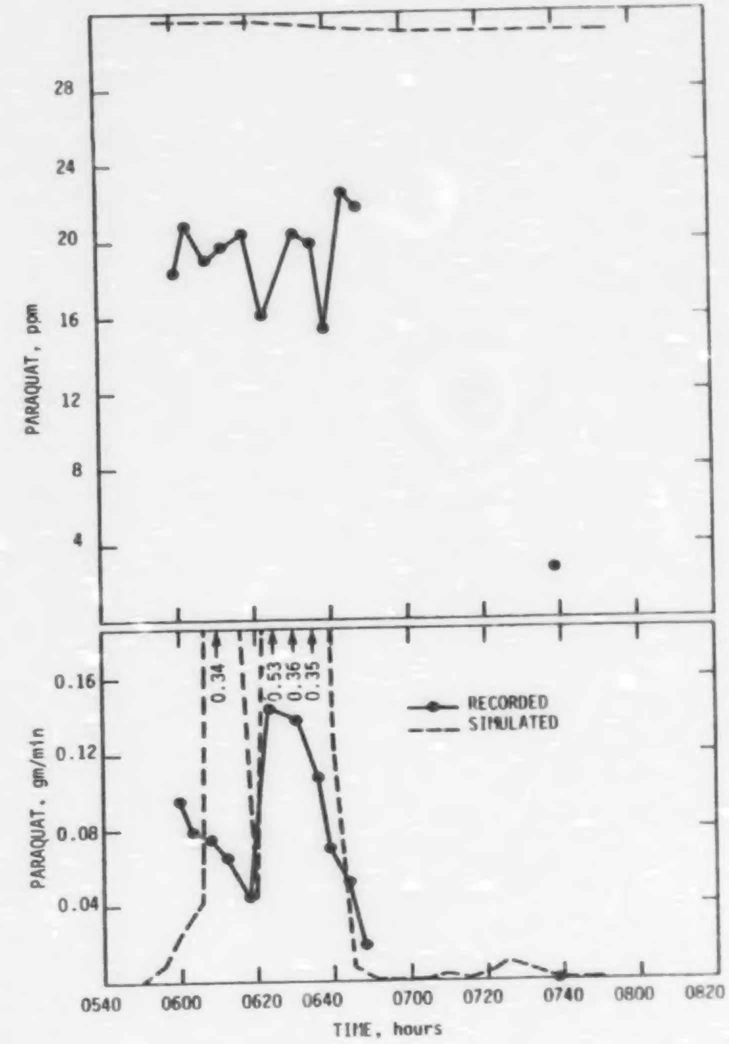


Figure C3 araquat removal on sediment from the P6 watershed for the storm of August 13, 1974

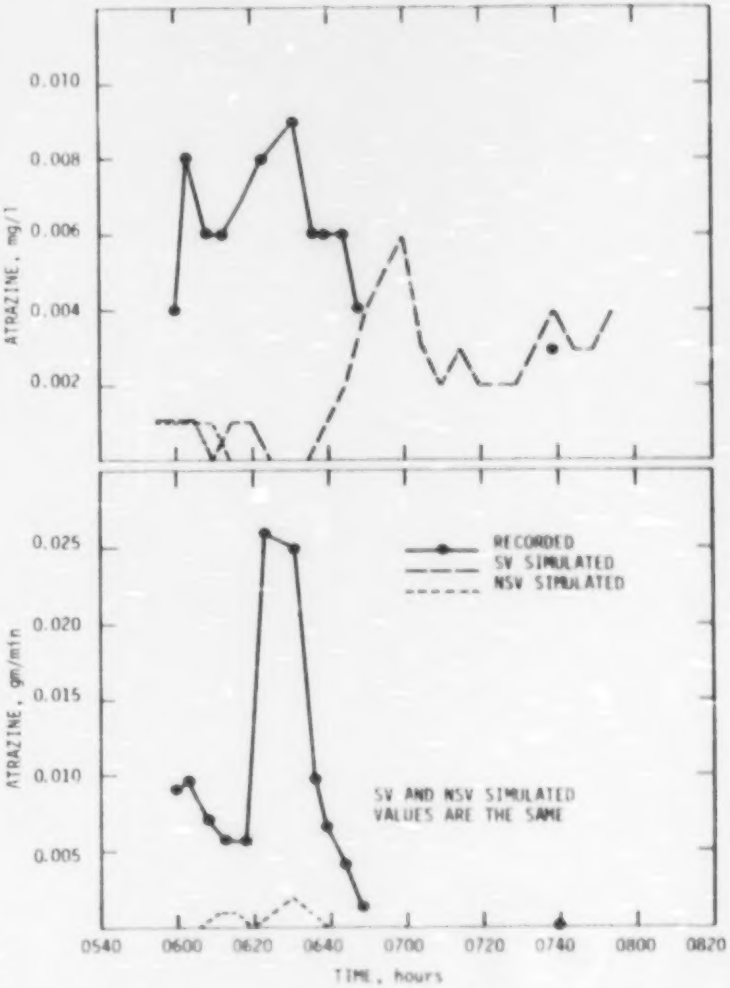


Figure C4 Atrazine removal in solution from the P6 watershed for the storm of August 13, 1974

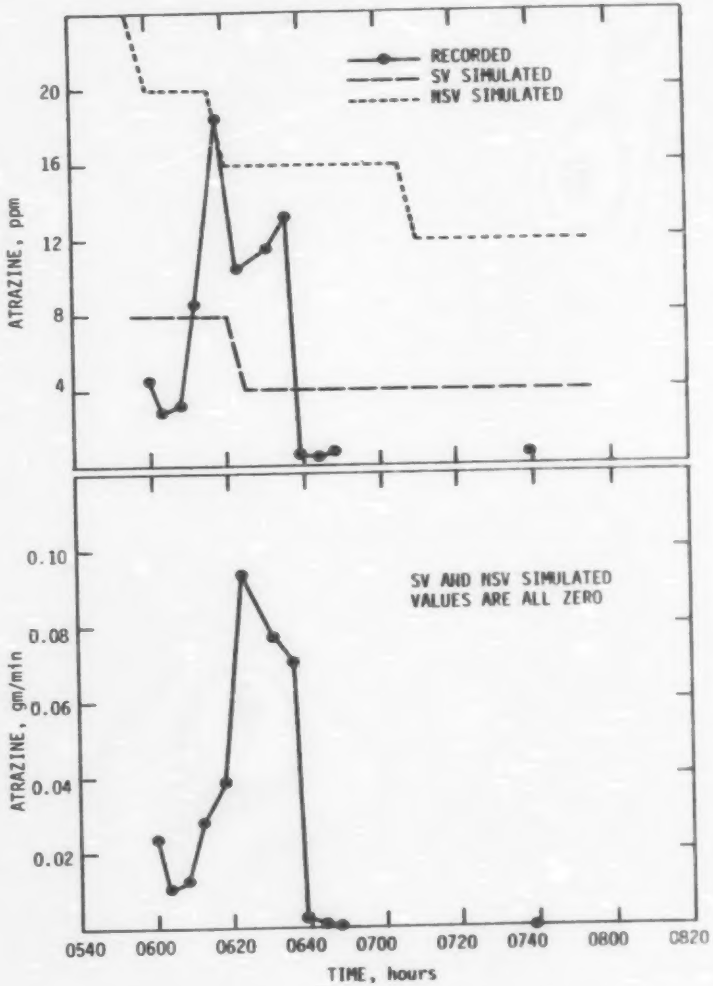


Figure C5 Atrazine removal on sediment from the P6 watershed for the storm of August 13, 1974

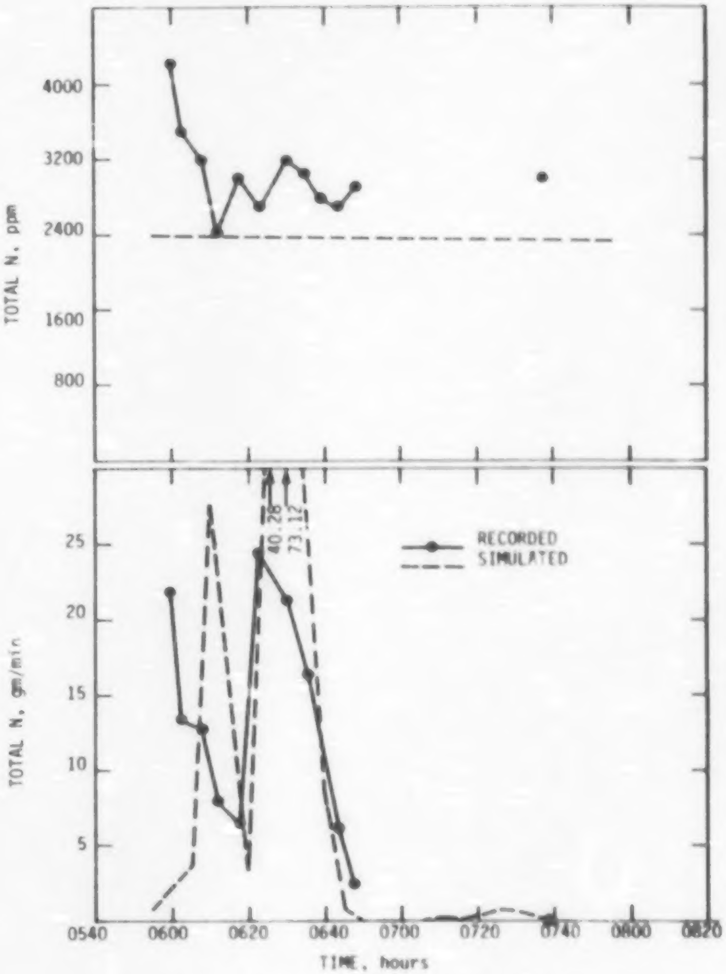


Figure C6 Total N removal on sediment from the P6 watershed for the storm of August 13, 1974

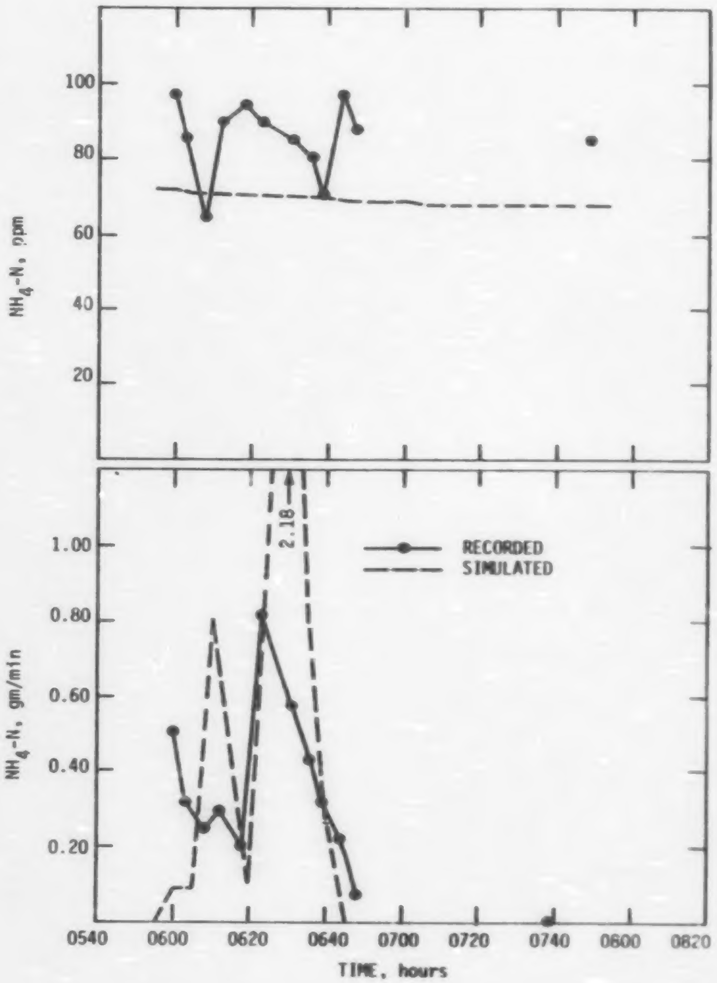


Figure C7 NH$_4$ removal on sediment from the P6 watershed for the storm of August 13, 1974

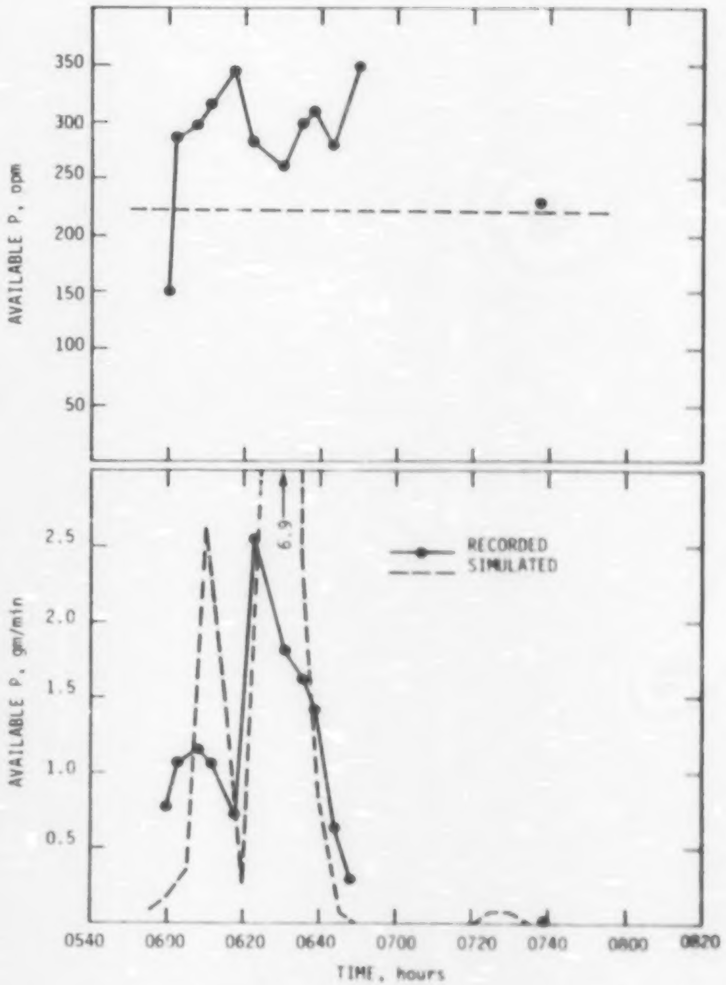


Figure C8 Available P removal on sediment from the P6 watershed for the storm of August 13, 1974

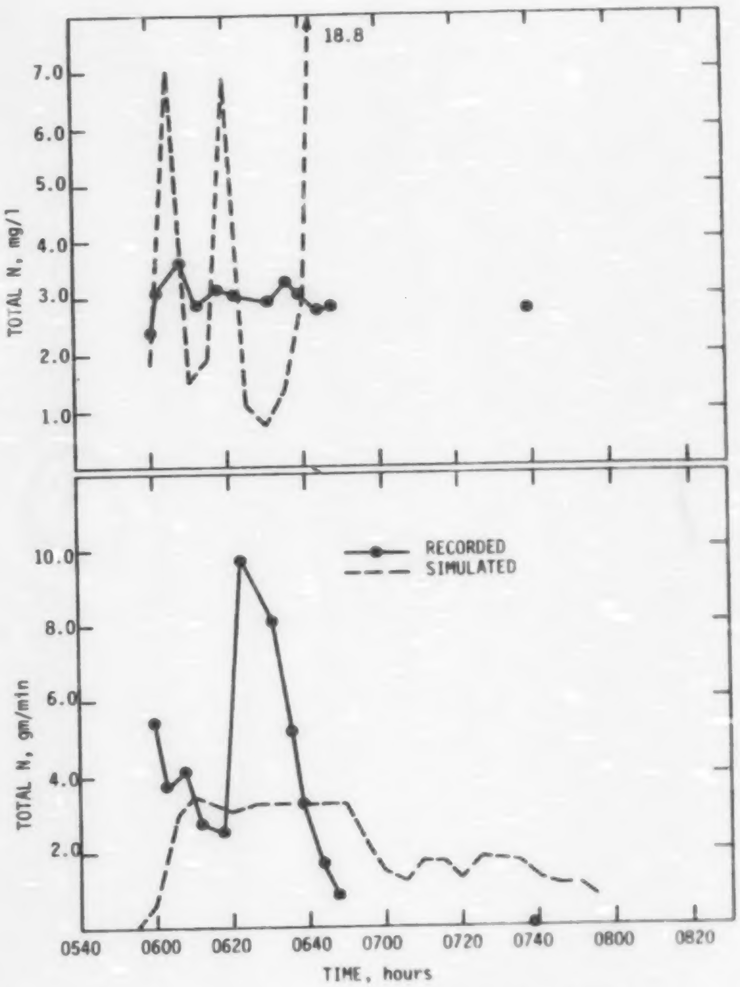


Figure C9 Total N removal in solution from the P6 watershed for the storm of August 13, 1974

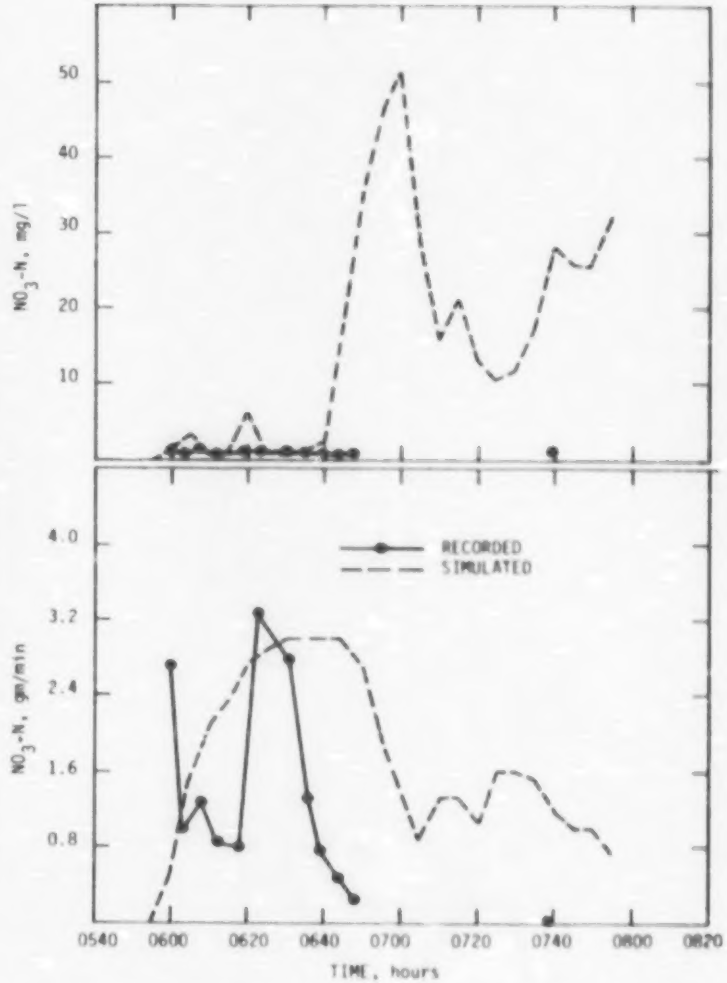


Figure C10 NO_3 removal in solution from the P6 watershed for the storm of August 13, 1974

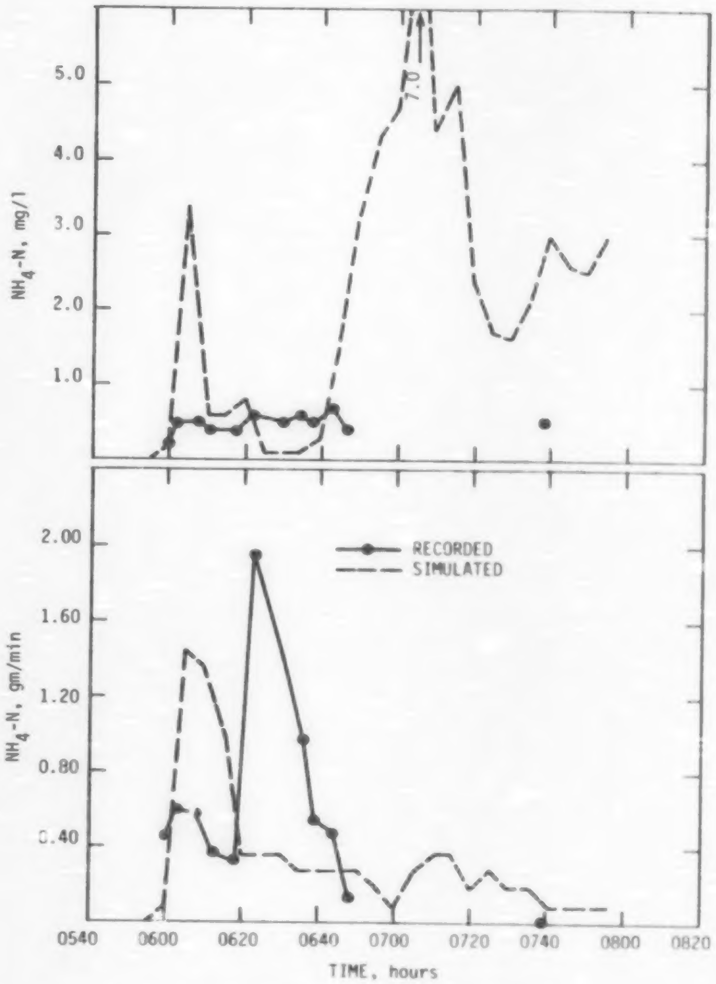


Figure C11 NH$_4$ removal in solution from the P6 watershed for the storm of August 13, 1974

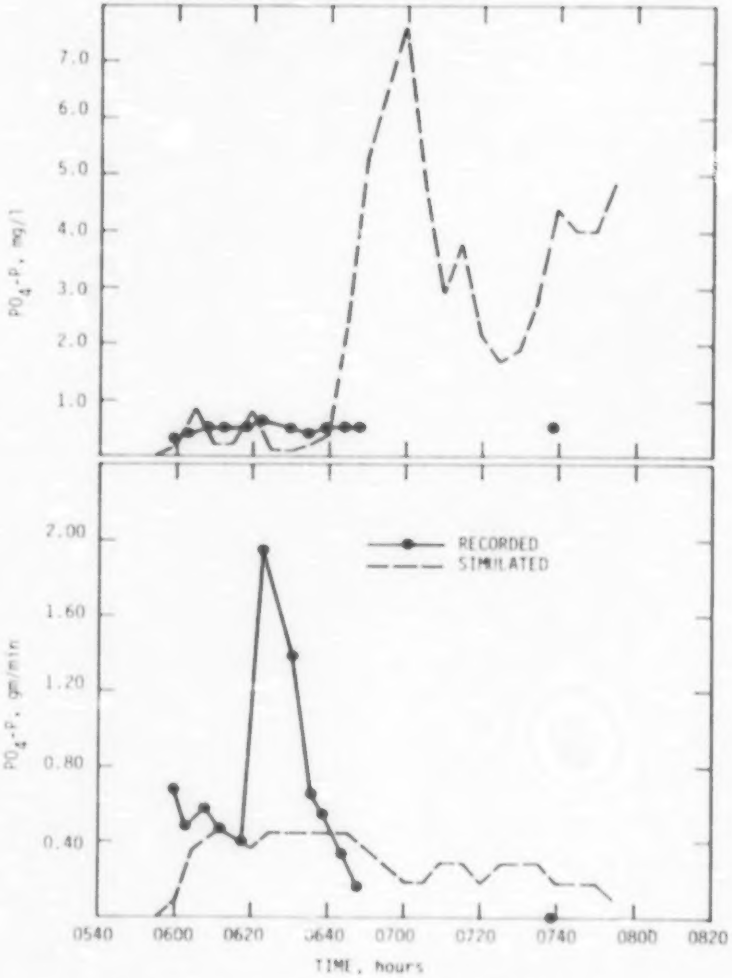


Figure C12 PO$_4$ removal in solution from the P6 watershed for the storm of August 13, 1974

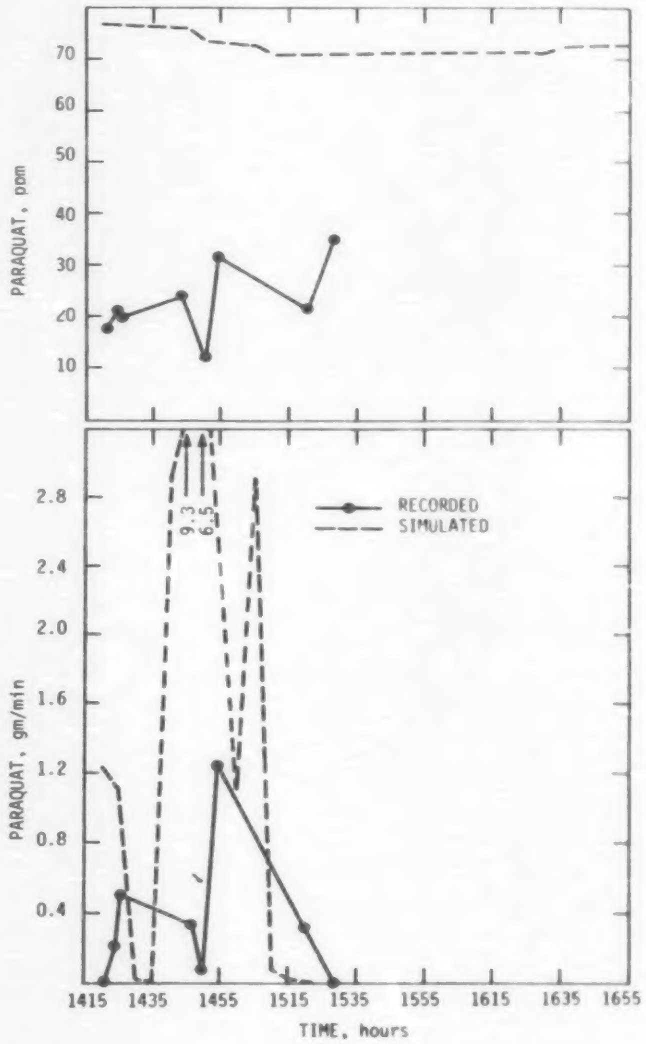


Figure C13 Paraquat removal on sediment from the P6 watershed for the storm of August 20, 1975

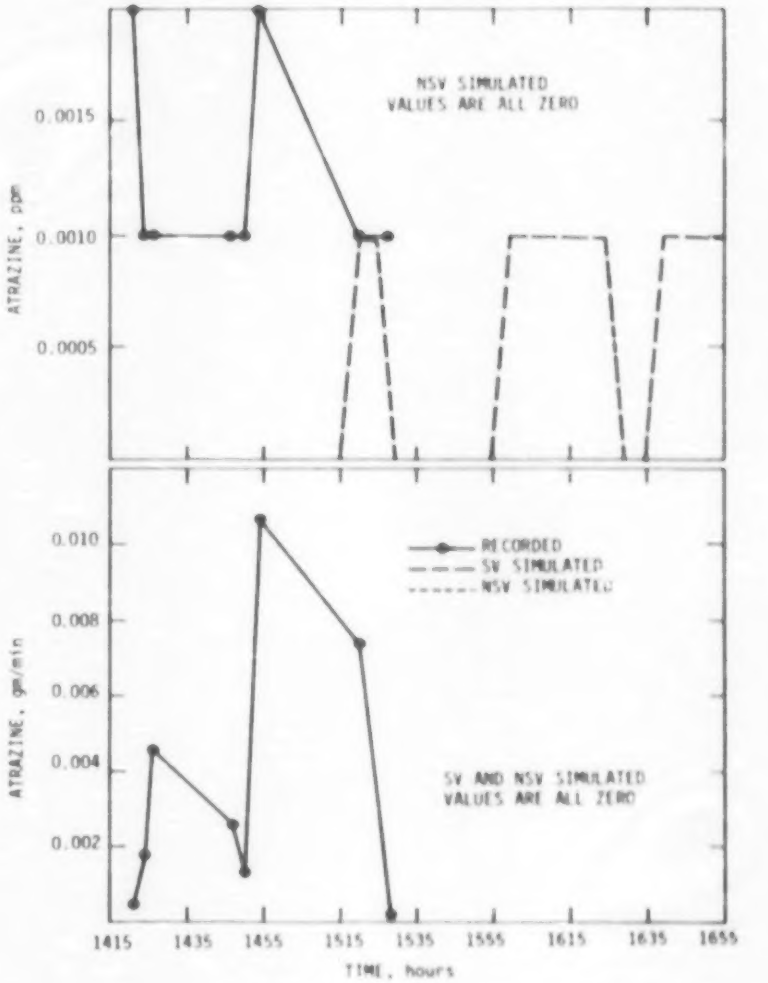


Figure C14 Atrazine removal in solution from the P6 watershed for the storm of August 20, 1975

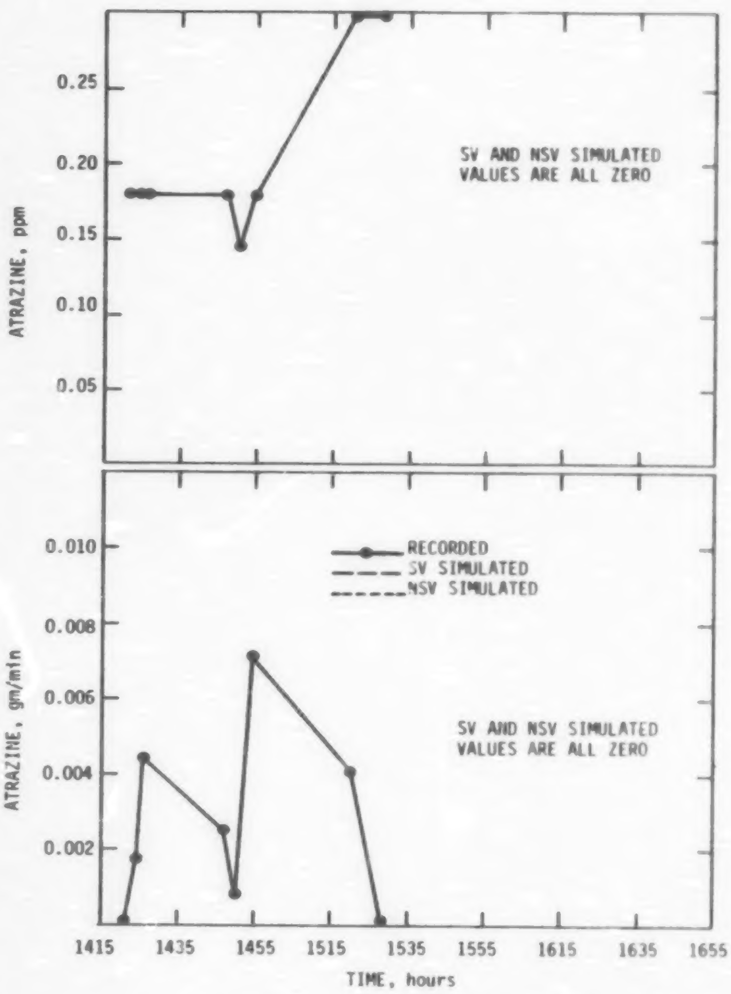


Figure C15 Atrazine removal on sediment from the P6 watershed for the storm of August 20, 1975

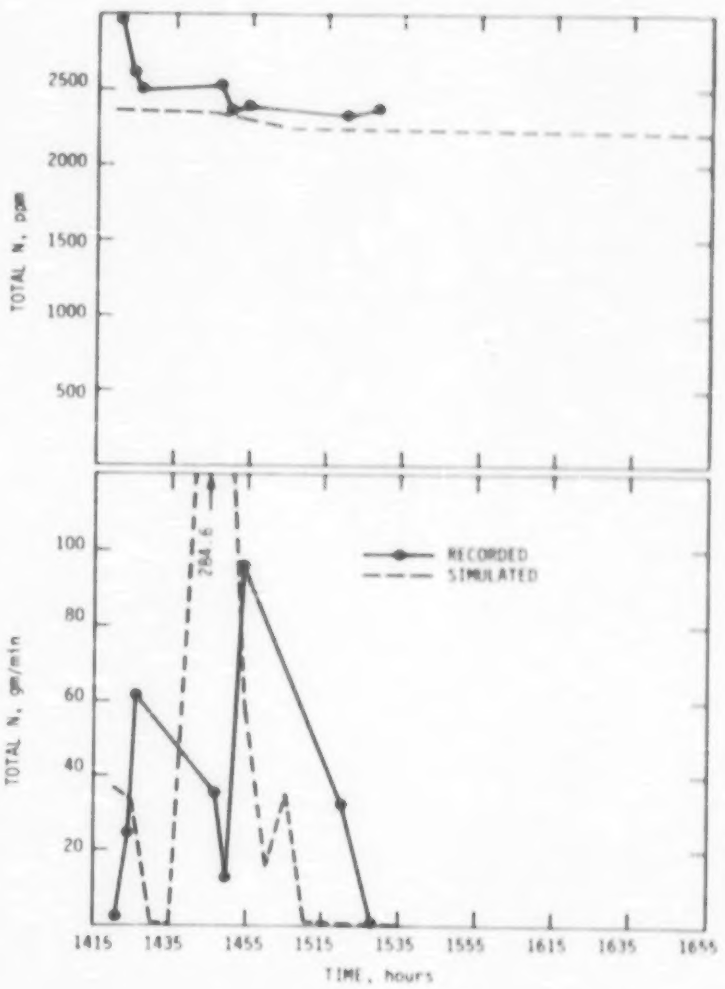


Figure C16 Total N removal in sediment from the P6 watershed for the storm of August 20, 1975

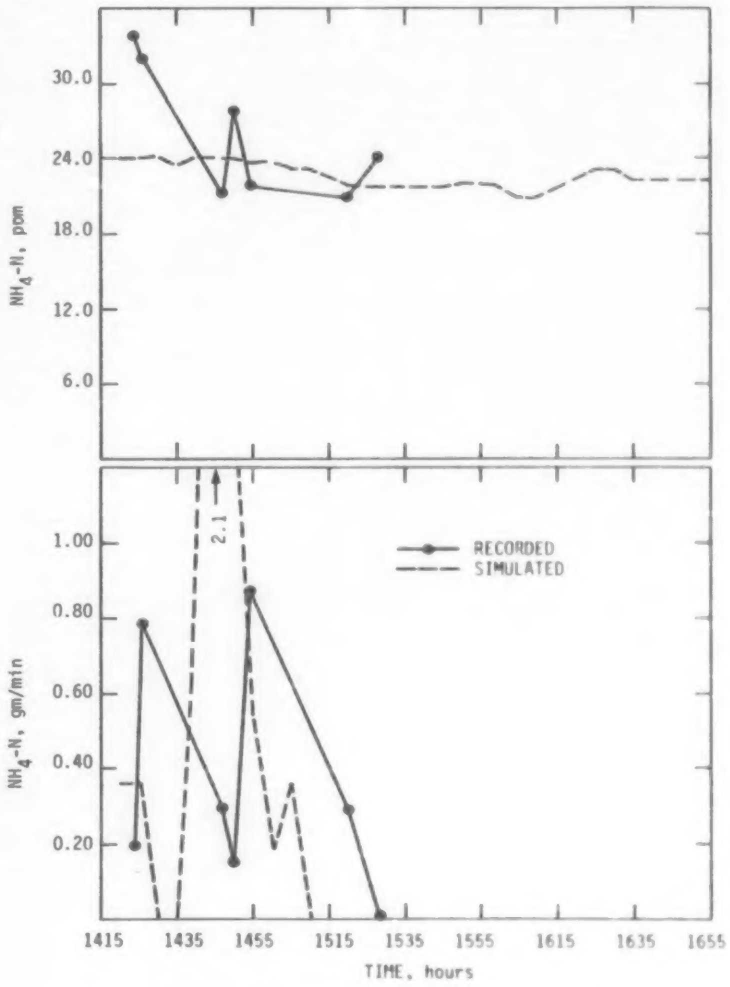


Figure C17 NH_4 removal on sediment from the P6 watershed for the storm of August 20, 1975

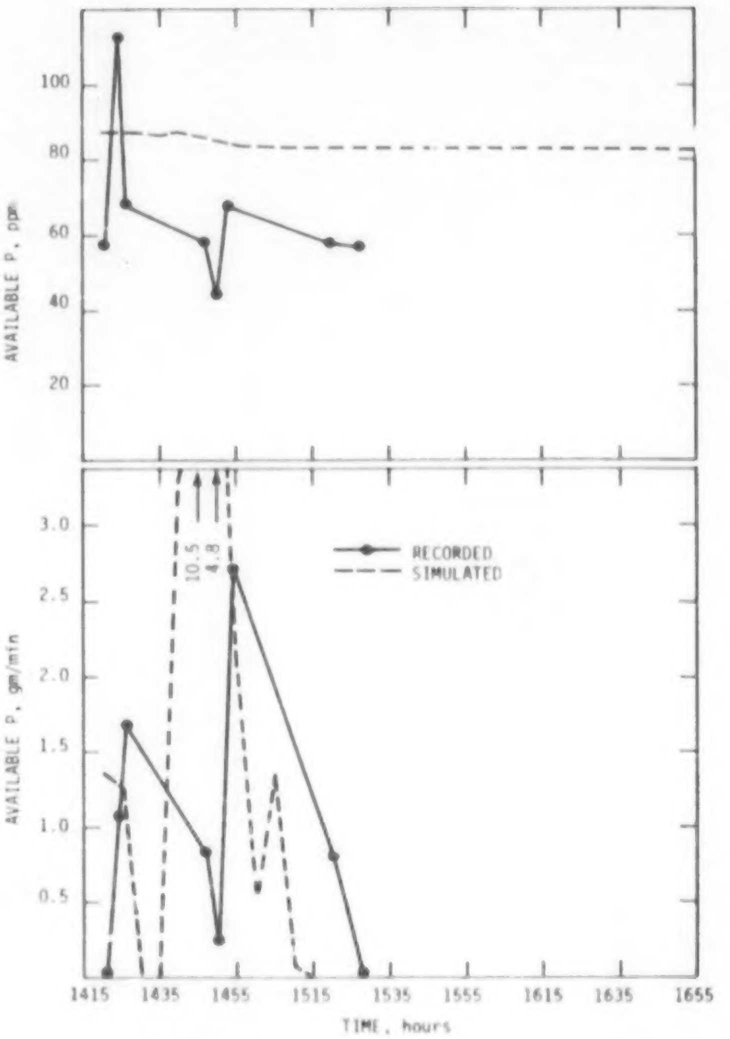


Figure C18 Available P removal on sediment from the P6 watershed for the storm of August 20, 1975

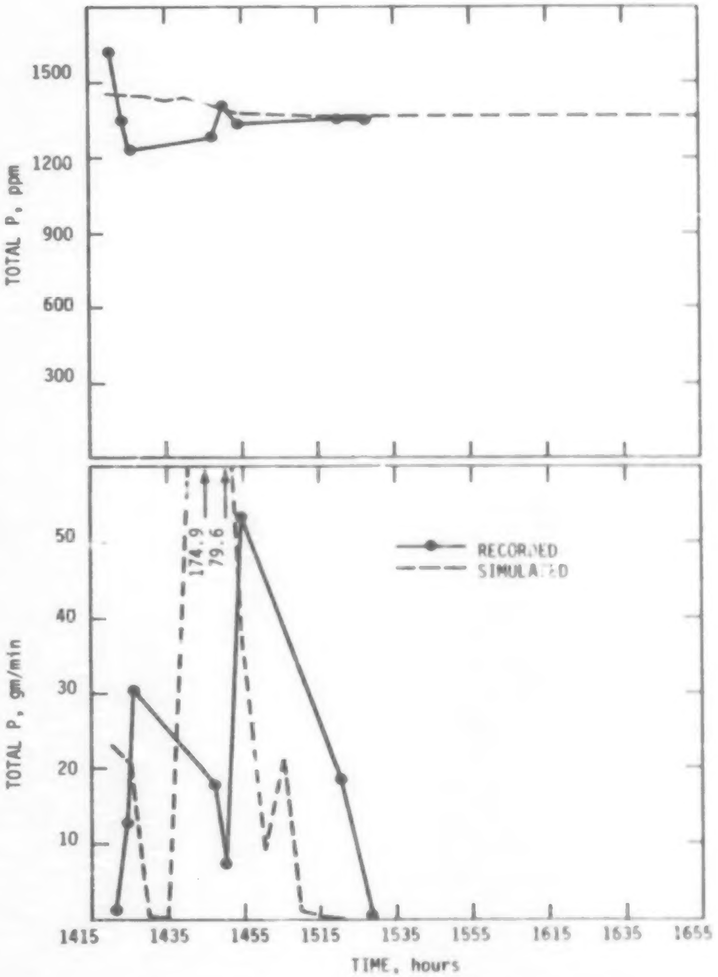


Figure C19 Total P removal on sediment from the P6 watershed for the storm of August 20, 1975

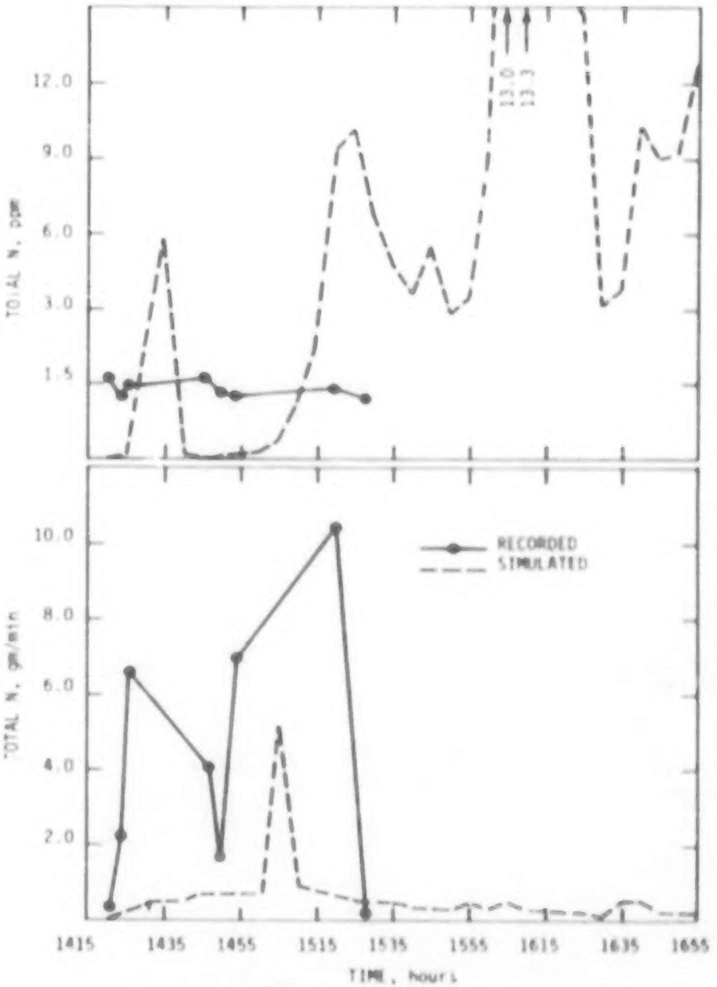


Figure C20 Total N removal in solution from the P6 watershed for the storm of August 20, 1975

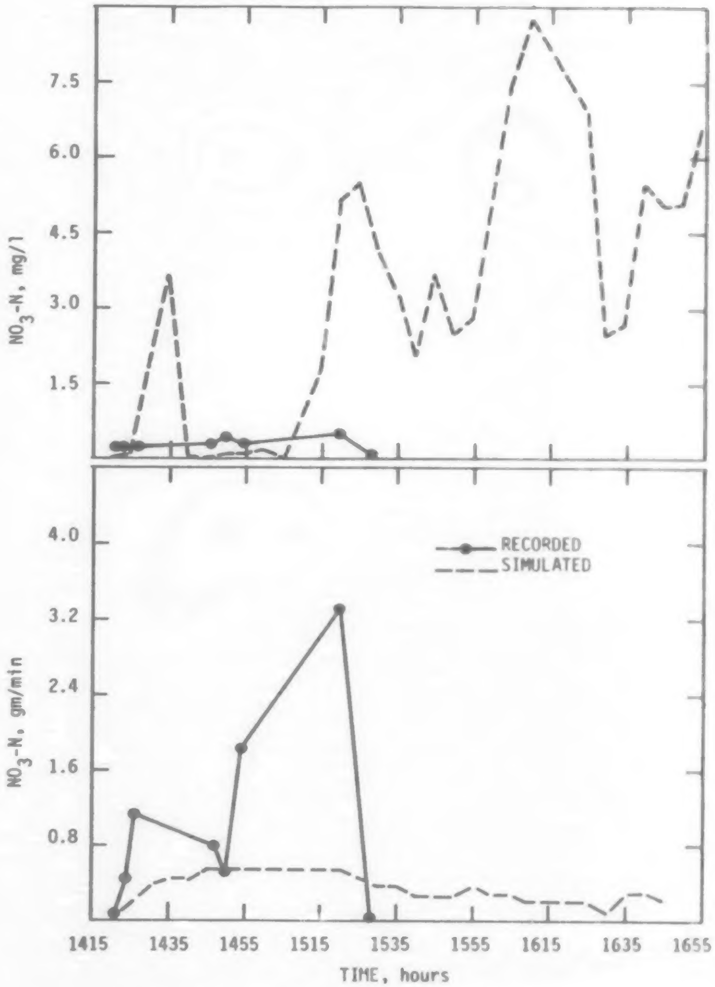


Figure C21 NO_3 removal in solution from the P6 watershed for the storm of August 20, 1975

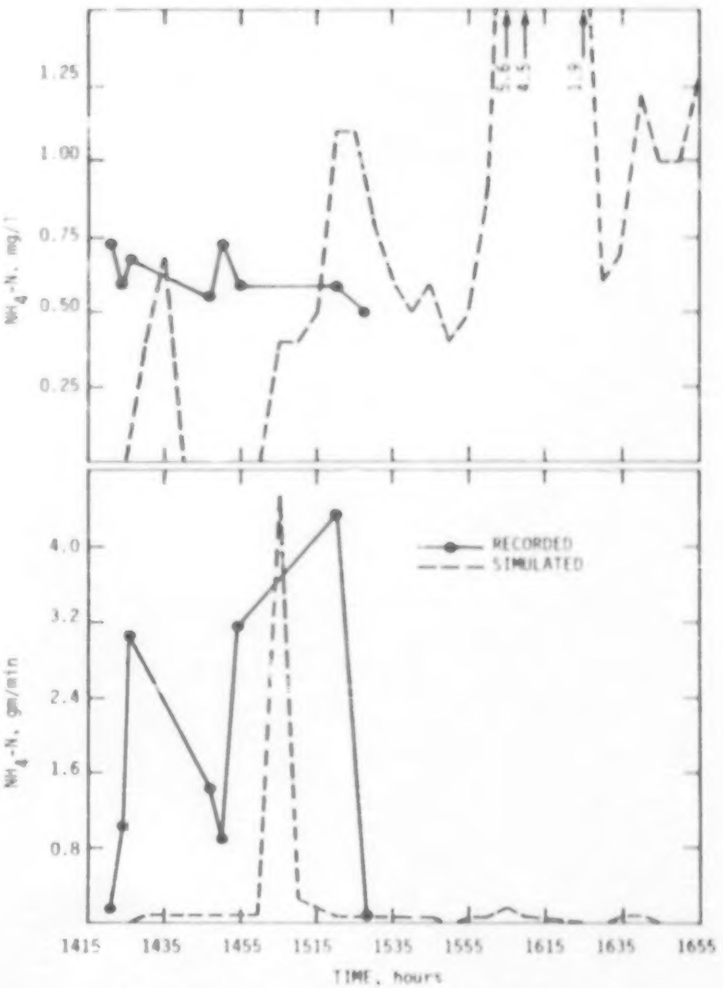


Figure C22 NH_4 removal in solution from the P6 watershed for the storm of August 20, 1975

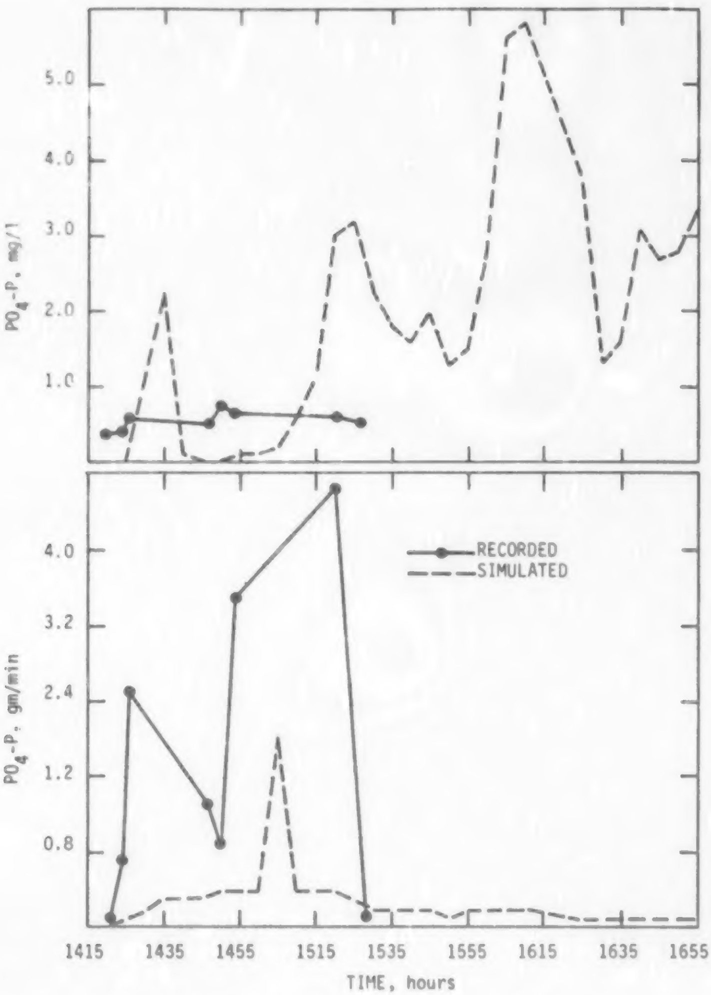


Figure C23 PO_4 removal in solution from the P6 watershed for the storm of August 20, 1975

APPENDIX D

ARM MODEL SOURCE CODE: VERSION II DATED 06/10/77

```
//HARL7508 JOB 'A19$X2,444,2,35','J7508 DAVIS ',CLASS=E,REGION=512K
// EXEC FORTCL,PARM.FORT='OPT=1,MAP,XREF',REGION.FORT=512K
//FORT.SYSPRINT DD SYSOUT=A
//FORT.SYSIN DD *
C
C
C
C      ***********************************************************
C      *                                                         *
C      *   AGRICULTURAL RUNOFF MANAGEMENT (ARM) MODEL - VERSION II   *
C      *                                                         *
C      ***********************************************************
C
C                                  DEVELOPED BY:  HYDROCOMP, INCORPORATED
C                                                 1502 PAGE MILL ROAD
C                                                 PALO ALTO, CA.  94304
C                                                   415-493-5522
C
C                                          FOR:   U.S. ENVIRONMENTAL
C                                                  PROTECTION AGENCY
C                                                 OFFICE OF RESEARCH
C                                                  AND DEVELOPMENT
C                                                 SOUTHEAST ENVIRONMENTAL
C                                                  RESEARCH LABORATORY
C                                                 ATHENS, GA.  30601
C                                                   404-546-3581
C
C
C                                                 VERSION: 10 JUNE 1977
C
C
C                                 MAIN PROGRAM
C
      IMPLICIT  REAL(L)
C
      DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
     1 UZSB(5),APERCB(5),RIB(5),ERSN(5),K3(12)
      DIMENSION SRER(5),ROBTOM(5),ROBTOT(5),INFTOM(5),INFTOT(5),
     1 ROITOM(5),ROITOT(5),RXB(5),ERSTOM(5),ERSTOT(5),MNAM(12),RAD(24),
     2 TEMPX(24),WINDX(24),RAIN(288),SRERMT(5),ERSNMT(5)
      DIMENSION IRAIN(288),IRAD(12,31),
     1 IWIND(12,31),ITEMP(12,31,2),GRAD(24),RADDIS(24),WINDIS(24),
     2 IEVAP(12,31),IDEW(12,31)
      DIMENSION WSNAME(20),CHNAME(20),COVPMO(12),DPM(12),TITLE(4,20)
      DIMENSION TIMTIL(12),YRTIL(12),SRERTL(12)
      DIMENSION LSRO(128),EROS(128),RROS(128),IDSN(4),ITYPE(4)
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1          STEMP(24),UTEMP(24),LZTEMP(12)
C
      COMMON /ALL/ RL,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
     2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
     3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
     4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
     1 ROTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,ROTOT,
     2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
     4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
     5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
     6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
     7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
     8 MELRAM,RADMEM,CORMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
     9 PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
     * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
     1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
     2 DSNFLO,DSNERS,LSRO,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
```

Reproduced from
best available copy.

```
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,JN,UNT,UNI,UNIT,
     1              UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2              SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3              TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4              KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5              TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      COMMON /PESTO/
     1 STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
     4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
C
C   COMMON ALL DECLARATIONS FOR I*2 & R*4
      INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
      REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
     1      UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
     2      LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
C   COMMON LAND DECLARATIONS FOR I*2 & R*4
      INTEGER  DAY,MONTH,DSNROS,DSNFLO,DSNERS,TMBLSZ,NEROS,
     1         NILSRC,NRROS
      REAL  SEVAPM,SUMSNY,PXSNY,MELRAY,RADMEY,CDRMEY,SGMY,CONMEY,
     1      CRAINY,SNEGMY,SEVAPY,TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,
     2      RXB,ROITOM,PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,
     3      IPACK,TMIN,SUMSNM,PXSNM,XK3,MELRAM,RADMEM,CDRMEM,CRAINM,
     4      CONMEM,SGMM,SNEGMM,PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,
     5      NEPTOM,RCSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,NEPTOT,
     6      RCSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     7      UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,
     8      KV,K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,
     9      SCEP1,SRGXT,SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,
     *      METOPT,CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,
     1      TSNOW,PETMIN,ROITOT,INFTOM,INFTOT,ERSTOM,ERSTOT,SRER,
     2      TEMPX,RAD,WINDX,RAIN,LSRO,EROS,RROS
C
      INTEGER  BGNDAY, BGNMON, BGNYR, ENDDAY, ENDMON, ENDYR
      INTEGER  YEAR, DYSTRT, DYEND, H, TIME
C
      INTEGER  IERROR, YR, MO, DY, CN, DA
      INTEGER  TIMPPT
      INTEGER  CSN
      INTEGER  DPM
C
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
      INTEGER*4  APMODE,DESORP,SURF,SOIL
C
      INTEGER*4  LOOP
      INTEGER*4  ICHECK
C
      INTEGER*4  BLANK1,BLANK2,CHNAME,DISK,WSNAME,SNOPRT
C
C
      INTEGER  TIMTIL, SFLAG ,YRTIL
C
      DOUBLE PRECISION  MNAM,PESTIC,ENDDIS,RUNOFF,SEDIME,OVERLA,CHAR
C
      REAL  UZDPTH,BDSZ,BDUZ,BDLZ,SZDPTH,COVPMO,RADCON
      REAL  PETMUL,WMUL,RMUL
      REAL  ICS
      REAL  N, MJ, ML
      REAL  SRRTMT, ERSNMT, NP
      REAL  KUGI
C
      REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
     2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
     3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
     4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
     5 UPRITT,UPRIS(5),SSTR(12)
C
      INTEGER TIMAP(12),YEARAP(12),KFLAG,DOG(12),YDG(12)
C
      REAL    K,NI,FPLZ,TOTPAP,PSSZ,PSUZ,PSLZ,PSGZ,
     2        KGPLB,FPLG,LSTR,LAS,LCS,LDS,GSTR,GAS,
     3        GCS,GDS,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     4        NIP,CEGLOM,DEGLOT,NCOM,DIST,SULG,KDG(12)
C
C     NUTRIENT VARIABLES -- DECLARED,DIMENSIONED,INITIALIZED
C
C
      INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      REAL  DELT,
     1        SNT(20),SNRSM(20,5),SNROM(20,5),
     2        UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
     3        NRSM(20,5),LNRPM(20),
     4        SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
     5        SNRSY(20,5),SNRDY(20,5),UNRIY(20,5),NRSY(20,5),
     6        LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
     7        TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
     8        KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
      DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
C
      REAL  SNAPL(20,5,5),UNAPL(20,5,5),KNI(8,4),KPI(5,4),UZF,LZF
      REAL  UZUPF(12),LZUPF(12)
C
      INTEGER  APDAY(5),APLCNT,JHOUR,NAPPL,J,IBLK,TIMHAR,
     1           SELHV(20),IOERR,INTRVL
      INTEGER DPMM1(12)
C
      DATA  TIMTIL/12*0/,YRTIL/12*0/,SRERTL/12*0.0/
      DATA  COVPMO/12*0.0/,BDSZ/103./,SZDPTH/.0625/,UZDPTH/6.0625/
      DATA  ICS, OFS/2*0.0/,BDUZ/103./,BDLZ/103./
C
      DATA BLANK1/'    '/,BLANK2/'    '/
C
      DATA K,NI,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     2 TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     3 DEGLOM,DEGLOT,NIP,NCOM,DIST,TOTPAP,SULG/25*0.0/
      DATA TIMAP/12*999/,YEARAP/12*0/,SSTR/12*0.0/
      DATA KGPLB/0.4536/, SURF/'SURF'/, SOIL/'SOIL'/
C
      DATA GRAD/0.04,0.04,0.03,0.02,
     *0.02,0.02,0.02,0.06,0.14,0.18,0.20,0.17,0.13,0.06,0.03,0.01,0.05,
     *0.07,0.10,0.13,0.15,0.13,0.12,0.08/
      DATA RADDIS/6*0.0,0.019,
     *0.041,0.067,0.088,0.102,0.110,0.110,0.110,0.105,0.095,0.081,0.055,
     *0.017,5*0.0/
      DATA WINDIS/7*0.034,0.035,
     *0.037,0.041,0.046,0.050,0.053,0.054,0.058,0.057,0.056,0.050,0.043,
     *0.040,0.038,0.036,0.036,0.035/
      DATA DPM/31,28,31,30,31,30,31,31,30,31,30,31/
      DATA PETMUL,WMUL,RMUL/3*1.0/
      DATA PESTIC/'PESTICID'/,ENDDIS/'ENDDISK'/,RUNOFF/'RUNOFF  '/,
     1SEDIME/'SEDIMENT'/,OVERLA/'OVERLAND'/
        DATA APLCNT/1/
        DATA SELHV/0,0,0,0,0,0,1,0,0,0,0,0,0,1,0,0,0,0,0,0/
      DATA DPMM1/0,31,28,31,30,31,30,31,31,30,31,30/
      DATA KFLAG/0/,ARDDL/0.0/
      DATA SFLAG/0/
      DATA KDG/12*0.0/
C
C                       DATA INPUT -- NAMELIST VARIABLES
```

```
C
C          NAMELIST IS SUPPORTED ON ONLY IBM COMPUTERS.  TO USE
C      NAMELIST REMOVE C FROM COLUMN 1 IN THE FOLLOWING NAMELIST
C      LIST AND IN THE NAMELIST READ STATEMENTS.  ADD C TO COLUMN
C      1 IN THE FORMATTED READ STATEMENTS TO DEACTIVATE THAT
C      SECTION OF CODE.
C
C
       NAMELIST /CNTL/  INTRVL,HYMIN,AREA
       NAMELIST /STRT/  BGNDAY,BGNMON,BGNYR
       NAMELIST /ENDD/  ENDDAY,ENDMON,ENDYR
       NAMELIST /LND1/  UZSN,UZS,LZSN,LZS
       NAMELIST /LND2/  L,SS,NN,A,EPXM,PETMUL
       NAMELIST /LND3/  K3
       NAMELIST /LND4/  INFIL,INTER,IRC,K24L,KK24,K24EL
       NAMELIST /LND5/  SGW,GWS,KV,ICS,OFS,IFS
       NAMELIST /SNO1/  RADCON,CCFAC,SCF,ELDIF,IDNS,F
       NAMELIST /SNO2/  DGM,WC,MPACK,EVAPSN,MELEV,TSNOW
       NAMELIST /SNO3/  PACK,DEPTH
       NAMELIST /SNO4/  PETMIN,PETMAX,WMUL,RMUL,KUGI
       NAMELIST /CROP/  COVPMO
       NAMELIST /MUD1/  TIMTIL
       NAMELIST /MUD2/  YRTIL
       NAMELIST /MUD3/  SRERTL
       NAMELIST /SMDL/  JRER,KRER,JSER,KSER,SRERI,SCMPAC
       NAMELIST /PSTR/  PSSZ,PSUZ,PSLZ,PSGZ
       NAMELIST /PST1/  TIMAP
       NAMELIST /PST2/  YEARAP
       NAMELIST /PST3/  SSTR
       NAMELIST /AMDL/  CMAX,DD,K,N,NP
       NAMELIST /DEGD/  DDG
       NAMELIST /DEGY/  YDG
       NAMELIST /DEGR/  KDG
       NAMELIST /LZTP/  LZTEMP
       NAMELIST /RETP/  ASZT,BSZT,AUZT,BUZT
       NAMELIST /DPTH/  SZDPTH,UZDPTH,BDSZ,BDUZ,BDLZ,UZF,LZF
C
C          INPUT PARAMETER DESCRIPTION
C WSNAME: WATERSHED NAME (72 CHARACTERS)
C CHNAME: CHEMICAL NAME (80 CHARACTERS)
C HYCAL : INDICATES WHAT FACTORS ARE TO BE SIMULATED
C       = PROD  PRODUCTION RUN
C       = CALB  CALIBRATION RUN
C INPUT : INPUT UNITS; ENGLISH(ENGL), METRIC(METR)
C OUTPUT: OUTPUT UNITS; ENGLISH(ENGL), METRIC(METR), BOT (BOTH)
C PRINT : DENOTES FREQUENCY OF OUTPUT; EACH INTERVAL(INTR),
C         EACH HOUR(HOUR), OR EACH DAY(DAYS),OR EACH MONTH(MNTH)
C SNOW  : (NO) SNOWMELT NOT PERFORMED, (YES) SNOWMELT CALC'S PERFORMED
C PEST  : (NO) PESTICIDES NOT PERFORMED, (YES) PESTICIDE CALC'S PERFORM
C NUTR  : (NO) NUTRIENTS NOT PERFORMED, (YES) NUTRIENT CALC'S PERFORMED
C ICHECK: CHECKS MOST OF THE INPUT IF SET EQUAL TO ON, OTHERWISE SET
C         TO OFF
C
C   DISK: (NO) NO INFORMATION WRITTEN TO DISK
C       : (YES) LSRO AND/OR EROS WRITTEN TO DISK
C
C ONLY IF DISK=YES SHOULD PARAMETERS IDEBUG THROUGH DSNERS BE INPUTTED
C
C IDEBUG: DEBUGGING OPTION FOR WRITING TO DISK
C       : (OFF)  NO DEBUG OUTPUT
C       : (ON)   PRINT ECHO OF INFO. WRITTEN TO DISK
C   CHAR: (RUNOFF) LSRO WRITTEN TO DISK
C       : (SEDIMENT) EROS WRITTEN TO DISK
C       : (OVERLAND) RROS WRITTEN TO DISK
C       : (ENDDISK) END OF DISK WRITING INFORMATION
C  TITLE: TITLE FOR DATA SET ON DISK (80 CHARS)
C DSNFLO: DATA SET NUMBER FOR LSRO FILE
C DSNERS: DATA SET NUMBER FOR EROS FILE
C DSNROS: DATA SET NUMBER FOR RROS FILE
```

```
C
C  INTRVL: TIME INTERVAL OF PRECIPITATION( 5 , 15 OR 60 MINUTES )
C  HYMIN : MINIMUM FLOW FOR OUTPUT DURING A TIME INTERVAL (CFS, CMS)
C  AREA  : WATERSHED AREA (AC, HA)
C  BGNDAY, BGNMON, BGNYR : DATE SIMULATION BEGINS
C  ENDDAY, ENDMON, ENDYR : DATE SIMULATION ENDS
C  UZSN  : NOMINAL UPPER ZONE STORAGE (IN, MM)
C  UZS   : INITIAL UPPER ZONE STORAGE (IN, MM)
C  LZSN  : NOMINAL LOWER ZONE STORAGE (IN, MM)
C  LZS   : INITIAL LOWER ZONE STORAGE (IN, MM)
C  L     : LENGTH OF OVERLAND FLOW TO CHANNEL (FT, M)
C  SS    : AVERAGE OVERLAND FLOW SLOPE
C  NN    : MANNING'S N FOR OVERLAND FLOW
C  A     : FRACTION OF AREA THAT IS IMPERVIOUS
C  K3    : INDEX TO ACTUAL EVAPORATION (12 MONTHLY VALUES)
C  EPXM  : MAXIMUM INTERCEPTION STORAGE (IN, MM)
C  INFIL : INFILTRATION RATE (IN/HR, MM/HR)
C  INTER : INTERFLOW PARAMETER, ALTERS RUNOFF TIMING
C  IRC   : INTERFLOW RECESSION RATE
C  K24L  : FRACTION OF GROUNDWATER RECHARGE PERCOLATING TO DEEP
C          GROUNDWATER
C  KK24  : GROUNDWATER RECESSION RATE
C  K24EL : FRACTION OF WATERSHED AREA WHERE GROUNDWATER IS WITHIN
C          REACH OF VEGETATION
C  SGW   : INITIAL GROUNDWATER STORAGE (IN, MM)
C  GWS   : GROUNDWATER SLOPE
C  KV    : PARAMETER TO ALLOW VARIABLE RECESSION RATE FOR GROUNDWATER
C          DISCHARGE
C  ICS   : INITIAL INTERCEPTION STORAGE (IN, MM)
C  OFS   : INITIAL OVERLAND FLOW STORAGE (IN, MM)
C  IFS   : INITIAL INTERFLOW STORAGE (IN, MM)
C
C  ONLY IF SNOW=YES SHOULD PARAMETERS SNOWPRINT THROUGH KUGI BE INPUTTED
C
C  SNOWPRINT: (NO) HOURLY SNOW TABLES NOT PRINTED DURING PERIODS
C                      OF SNOWPACK
C                 (YES) HOURLY SNOW TABLES PRINTED
C  RADCON: CORRECTION FACTOR FOR RADIATION
C  CCFAC : CORRECTION FACTOR FOR CONDENSATION AND CONVECTION
C  SCF   : SNOW CORRECTION FACTOR FOR RAINGAGE CATCH DEFICIENCY
C  ELDIF : ELEVATION DIFFERENCE FROM TEMP. STATION TO MEAN SEGMENT ELEVA
C          (1000 FT, KM)
C  IDNS  : DENSITY OF NEW SNOW AT 0 DEGREES F.
C  F     : FRACTION OF SEGMENT WITH COMPLETE FOREST COVER
C  DGM   : DAILY GROUNDMELT (IN/DAY, MM/DAY)
C  WC    : MAXIMUM WATER CONTENT OF SNOWPACK BY WEIGHT
C  MPACK : ESTIMATED WATER EQUIVALENT OF SNOWPACK FOR COMPLETE COVERAGE
C  EVAPSN: CORRECTION FACTOR FOR SNOW EVAPORATION
C  MELEV : MEAN ELEVATION OF WATERSHED (FT, M)
C  TSNOW : TEMPERATURE BELOW WHICH SNOW FALLS (F, C)
C  PACK  : INITIAL WATER EQUIVALENT OF SNOWPACK (IN, MM)
C  DEPTH : INITIAL DEPTH OF SNOWPACK (IN, MM)
C  PETMIN: TEMPERATURE AT WHICH ZERO PET OCCURS (F, C)
C  PETMAX: TEMPERATURE AT WHICH PET IS REDUCED BY 50% (F, C)
C  PETMUL: POTENTIAL EVAPOTRANSPIRATION MULTIPLICATION FACTOR
C  WMUL  : WIND MULTIPLICATION FACTOR
C  RMUL  : RADIATION MULTIPLICATION FACTOR
C  KUGI  : INDEX TO FOREST DENSITY AND UNDERGROWTH (0.0-10.0)
C
C  CCVPMO: PERCENTAGE CROP COVER ON MONTHLY BASIS
C  TIMTIL: TIME (IN JULIAN DAYS) WHEN SOIL IS TILLED
C  YRTIL : THE CORRESPONDING YEAR IN WHICH TIMTIL APPLIES
C  SRERTL: FINE DEPOSITS PRODUCED BY TILLAGE (TONS/ACRE, TONNES/HECTARE)
C  JRER  : EXPONENT OF RAINFALL INTENSITY  IN SOIL SPLASH EQUATION
C  KRER  : COEFFICIENT IN SOIL SPLASH EQUATION
C  JSER  : EXPONENT OF OVERLAND FLOW IN SURFACE SCOUR EQUATION
C  KSER  : COEFFICIENT IN SURFACE SCOUR EQUATION
```

```
C  SPEKI : INITIAL FINES DEPOSIT (TONS/ACRE, TONNES/HECTARE)
C  SCMPAC: RATE BY WHICH SOIL FINES ARE DECREASED PER DAY (ONLY ON
C          NON-RAIN DAYS)
C
C  ONLY IF PEST=YES SHOULD TITLE PESTICIDE AND PARAMETERS APMODE
C  THROUGH BK BE INPUTTED
C
C  TITLE WORD PESTICIDE MUST BE INCLUDED IN THE INPUT SEQUENCE
C  PRIOR TO ANY PESTICIDE INPUT PARAMETERS
C
C  APMODE: APPLICATION MODE; SURFACE APPLIED (SURF),
C                            SOIL INCORPORATED (SOIL)
C  DESORP: (NO) ONLY ADSORPTION ALGORITHM USED, (YES) BOTH ADSORPTION
C          AND DESORPTION USED
C  PSSZ  : INITIAL PESTICIDE STORAGE IN SURFACE ZONE (LB/AC, KG/HA)
C  PSUZ  : INITIAL PESTICIDE STORAGE IN UPPER ZONE (LB/AC, KG/HA)
C  PSLZ  : INITIAL PESTICIDE STORAGE IN LOWER ZONE (LB/AC, KG/HA)
C  PSGZ  : INITIAL PESTICIDE STORAGE IN GROUNDWATER ZONE (LB/AC, KG/HA)
C  SSTR  : PESTICIDE APPLICATION FOR ENTIRE WATERSHED (LB/AC, KG/HA)
C  TIMAP : TIME OF PESTICIDE APPLICATION (JULIAN DAY)
C  YEARAP: THE CORRESPONDING YEAR IN WHICH TIMAP APPLIES
C  CMAX  : MAXIMUM SOLUBILITY OF PESTICIDE IN WATER (LB/LB)
C  DD    : PERMANENTLY FIXED CAPACITY (LB PESTICIDE/LB SOIL)
C  K     : COEFICIENT IN FREUNDLICH ADSORPTION CURVE
C  N     : EXPONENT IN FREUNLICH ADSORPTION CURVE
C  NP    : DESORPTION EXPONENT IN FREUNDLICH CURVE
C  DDG   : JULIAN DAY WHEN KDG(I) BEGINS (MAX. OF 12 VALUES)
C  YDG   : CORRESPONDING YEAR IN WHICH DDG APPLIES
C  KDG   : PESTICIDE DECAY RATE (PER DAY) (MAX. 12 VALUES)
C
C          FOLLOWING ARE TO INPUTTED FOR NUTR=YES OR PEST=YES
C
C  SZDPTH: SURFACE LAYER SOIL DEPTH (IN THE RANGE OF 1/8 INCH) (IN, MM)
C  UZDPTH: DEPTH OF SOIL INCORPORATION AND UPPER ZONE (IN, MM)
C  BDSZ  : BULK DENSITY OF SURFACE LAYER SOIL (LB/FT(3)), (G/CM(3))
C  BDUZ  : BULK DENSITY OF UPPER ZONE SOIL (LB/FT(3), (G/CM(3))
C  BDLZ  : BULK DENSITY OF LOWER ZONE SOIL (LB/FT(3), (G/CM(3))
C  ASZT  : SLOPE OF SURFACE ZONE SOIL TEMPERATURE REGRESSION EQN.
C  BSZT  : Y-INTERCEPT OF SURFACE ZONE SOIL TEMPERATURE REGRESSION EQN.
C  AUZT  : SLOPE OF UPPER ZONE SOIL TEMPERATURE REGRESSION EQN.
C  BUZT  : Y-INTERCEPT OF UPPER ZONE TEMPERATURE REGRESSION EQN.
C  UZF   : UPPER ZONE CHEMICAL PERCOLATION  FACTOR
C  LZF   : LOWER ZONE CHEMICAL PERCOLATION FACTOR
C
C TURN OFF UNDERFLOW ABORT ON HP3000
C
C     ON REAL UNDERFLOW CALL ERRSET
C
      READ (5,1096) (WSNAME(I),I=1,20)
C
C   CHECK FOR RUNNING NUMBERED ON WYLBUR
C
      IF(WSNAME(19).EQ.BLANK1.AND.WSNAME(20).EQ.BLANK2) GO TO 10
      WRITE(6,1079) WSNAME(19).WSNAME(20)
      STOP
C
   10 READ (5,1096) (CHNAME(I),I=1,20)
      READ (5,1097)  HYCAL
      READ (5,1097)  INPUT
      READ (5,1098)  OUTPUT
      READ (5,1097)  PRINT
      READ (5,1099)  SNOW
      READ (5,1099)  PEST
      READ (5,1099)  NUTR
      READ (5,1098)  ICHECK

C                    READ DISK INFORMATION
C
```

Reproduced from
best available copy.

```
      IDKCNT = 0
      READ (5,1099) DISK
      IF (DISK .EQ. NO) GO TO 20
C
      READ (5,1097) IDEBUG
   12 READ (5,1100) CHAR
      IF (CHAR .EQ. ENDDIS)  GO TO 20
      IF (CHAR .NE. RUNOFF)  GO TO 14
      IDKCNT = IDKCNT + 1
C
      READ (5,1096) (TITLE(IDKCNT,I),I=1,20)
      READ (5,1083) DSNFLO
      IDSN(IDKCNT) = DSNFLO
      ITYPE(IDKCNT) = 1
      GO TO 12
C
   14 IF (CHAR .NE. SEDIME)  GO TO 16
      IDKCNT = IDKCNT + 1
      READ (5,1096) (TITLE(IDKCNT,I),I=1,20)
      READ (5,1083) DSNERS
      IDSN(IDKCNT) = DSNERS
      ITYPE(IDKCNT) = 2
      GO TO 12
C
   16 IF (CHAR .NE. OVERLA)  GO TO 18
      IDKCNT = IDKCNT + 1
      READ (5,1096) (TITLE(IDKCNT,I),I=1,20)
      READ (5,1083) DSNROS
      IDSN(IDKCNT) = DSNROS
      ITYPE(IDKCNT) = 2
      GO TO 12
C
   18 WRITE (6,1084) CHAR
      STOP
C
C
C                        DATA INPUT -- NAMELIST VARIABLES
C
C          NAMELIST IS SUPPORTED ON ONLY IBM COMPUTERS.  TO USE
C     NAMELIST REMOVE C FROM COLUMN 1 IN THE FOLLOWING NAMELIST
C     READ STATEMENTS.  ADD C TO COLUMN 1 IN THE FORMATTED READ
C     STATEMENTS (DIRECTLY BELOW) TO DEACTIVATE THAT SECTION
C     OF CODE.
C
C
C
   20 READ (5,CNTL)
      READ (5,STRT)
      READ (5,ENDD)
      READ (5,LND1)
      READ (5,LND2)
      READ (5,LND3)
      READ (5,LND4)
      READ (5,LND5)
C
      IF (SNOW .EQ. NO)  GO TO 400
      READ (5,5013)  SNOPRT
      READ (5,SNO1)
      READ (5,SNO2)
      READ (5,SNO3)
      READ (5,SNO4)
C
  400 READ (5,CROP)
      READ (5,MUD1)
      READ (5,MUD2)
      READ (5,MUD3)
      READ (5,SMDL)
C
```

```
      IF (PEST .EQ. NO)  GO TO 402
      READ (5,1100)  CHAR
      IF (CHAR .EQ. PESTIC)  GO TO 401
          WRITE (6,1122)
          GO TO 1080
C
  401 READ (5,1098)  APMODE
      READ (5,1098)  DESCRP
      READ (5,PSTR)
      READ (5,PST1)
      READ (5,PST2)
      READ (5,PST3)
      READ (5,AMDL)
      READ (5,DEGC)
      READ (5,DEGY)
      READ (5,DEGR)
C
C
C  20 READ (5,5000) INTRVL,HYMIN,AREA
C     READ (5,5001) BGNDAY,BGNMON,BGNYR
C     READ (5,5001) ENDDAY,ENDMON,ENDYR
C     READ (5,5002) UZSN,UZS,LZSN,LZS
C     READ (5,5003) L,SS,NN,A,EPXM,PETMUL
C     READ (5,5004) (K3(I),I=1,12)
C     READ (5,5003) INFIL,INTER,IRC,K24L,KK24,K24EL
C     READ (5,5003) SGW,GWS,KV,ICS,OFS,IFS
C
C     IF (SNOW .EQ. NO)  GO TO 400
C     READ (5,5013) SNOPRT
C     READ (5,5003) RADCON,CCFAC,SCF,ELDIF,IDNS,F
C     READ (5,5003) DGM,WC,MPACK,EVAPSN,MELEV,TSNOW
C     READ (5,5005) PACK,DEPTH
C     READ (5,5006) PETMIN,PETMAX,WMUL,RMUL,KUGI
C
C 400 READ (5,5004) (COVPMO(I),I=1,12)
C     READ (5,5009) (TIMTIL(I),I=1,12)
C     READ (5,5009) (YRTIL(I),I=1,12)
C     READ (5,5004) (SRERTL(I),I=1,12)
C     READ (5,5003) JRER,KRER,JSER,KSER,SRERI,SCMPAC
C
C     IF (PEST .EQ. NO)  GO TO 402
C     READ (5,1100)  CHAR
C     IF (CHAR.EQ.PESTIC)  GO TO 401
C         WRITE (6,1122)
C         GO TO 1080
C
C 401 READ (5,1098)  APMODE
C     READ (5,1098)  DESCRP
C     READ (5,5002) PSSZ,PSUZ,PSLZ,PSGZ
C     READ (5,5009) (TIMAP(I),I=1,12)
C     READ (5,5009) (YEARAP(I),I=1,12)
C     READ (5,5004) (SSTR(I),I=1,12)
C     READ (5,5006) CMAX,DD,K,N,NP
C     READ (5,5009) (LDG(I),I=1,12)
C     READ (5,5009) (YDG(I),I=1,12)
C     READ (5,5004) (KDG(I),I=1,12)
C
C
C                   PRINTING OF INPUT PARAMETERS
C
  402 IF (HYCAL.EQ.CALB)  GO TO 1002
          WRITE (6,1091)
          IF (PEST.EQ.YES.AND.NUTR.EQ.NO)  WRITE (6,1123)
          IF (PEST.EQ.NO .AND.NUTR.EQ.YES) WRITE (6,1124)
          IF (PEST.EQ.NO .AND.NUTR.EQ.NO)  WRITE (6,1125)
          IF (PEST.EQ.YES.AND.NUTR.EQ.YES) WRITE (6,1126)
          WRITE (6,1092)
          GO TO 1003
```

```
C
 1002 WRITE (6,1093)
            IF (PEST.EQ.YES.AND.NUTR.EQ.NO)  WRITE (6,1123)
            IF (PEST.EQ.NO .AND.NUTR.EQ.YES) WRITE (6,1124)
            IF (PEST.EQ.NO .AND.NUTR.EQ.NO)  WRITE (6,1125)
            WRITE (6,1092)
            IF (PEST.EQ.NO .OR. NUTR.EQ.NO)  GO TO 1003
            WRITE (6,1121)
            GO TO 1080
C
 1003 WRITE (6,1107) (WSNAME(I),I=1,20)
      WRITE (6,1106) (CHNAME(I),I=1,20)
      IF (INPUT .EQ. ENGL)  WRITE (6,1108)
      IF (INPUT .EQ. METR)  WRITE (6,1109)
      IF (OUTPUT .EQ. ENGL) WRITE (6,1110)
      IF (OUTPUT .EQ. METR) WRITE (6,1111)
      IF (OUTPUT .EQ. BOTH) WRITE (6,1112)
      IF (PRINT .EQ. INTR)  WRITE (6,1113)
      IF (PRINT .EQ. HOUR)  WRITE (6,1114)
      IF (PRINT .EQ. DAYS)  WRITE (6,1115)
      IF (PRINT .EQ. MNTH)  WRITE (6,1128)
      IF (SNOW .EQ. YES)    WRITE (6,1116)
      IF (SNOW .EQ. NO)     WRITE (6,1117)
      IF (PEST .EQ. NO)  GO TO 1010
      IF (DESORP .EQ. YES)  WRITE (6,1118)
      IF (DESORP .EQ. NO)   WRITE (6,1119)
      IF (APMODE .EQ. SOIL)  WRITE (6,1105)
      IF (APMODE .EQ. SURF)  WRITE (6,1104)
 1010 WRITE (6,1092)
C
      IF (DISK .EQ. NO)  WRITE (6,1088)
      IF (IDKCNT .EQ. 0)  GO TO 40
      IF (IDEBUG .EQ. ON)  WRITE (6,9996)
      WRITE (6,1085)
      DO 34 JDISK=1,IDKCNT
         WRITE (6,1086) IDSN(JDISK)
         WRITE (6,1089) (TITLE(JDISK,I),I=1,20)
         DO 32 I=1,20
   32       LSRO(I) = TITLE(JDISK,I)
         LSRO(21) = 0
         LSRO(22) = BGNDAY
         LSRO(23) = BGNMON
         LSRO(24) = BGNYR
         LSRO(25) = 23
         LSRO(26) = ENDDAY
         LSRO(27) = ENDMON
         LSRO(28) = ENDYR
         LSRO(29) = INTRVL*60.
         IF (INTRVL.EQ.60) LSRO(29) = 900.
         LSRO(30) = ITYPE(JDISK)
C
         DSN = IDSN(JDISK)
         WRITE(DSN) LSRO
   34 CONTINUE
C
C
   40 WRITE (6,1164) INTRVL,HYMIN,AREA
      WRITE (6,1165) BGNDAY,BGNMON,BGNYR
      WRITE (6,1166) ENDDAY,ENDMON,ENDYR
      WRITE (6,1167) UZSN,UZS,LZSN,LZS
      WRITE (6,1168) L,SS,NN,A,EPXM,PETMUL
      WRITE (6,1162) (K3(I),I=1,12)
      WRITE (6,1169) INFIL,INTER,IRC,K24L,KK24,K24EL
      WRITE (6,1170) SGW,GWS,KV,ICS,OFS,IFS
      IF (SNOW .EQ. NO) GO TO 1011
      WRITE (6,1171) RADCON,CCFAC,SCF,ELDIF,IDNS,F
      WRITE (6,1172) CGM,WC,MPACK,EVAPSN,MELEV,TSNOW
      WRITE (6,1173) PACK,DEPTH
      WRITE (6,1174) PETMIN,PETMAX,WMUL,RMUL,KUGI
 1011 WRITE (6,1175) (COVPMO(I),I=1,12)
      WRITE (6,1183)(TIMTIL(I),I=1,12),(YRTIL(I),I=1,12),
     1       (SRERTL(I),I=1,12)
      WRITE (6,1177) JRER,KRER,JSER,KSER,SRERI,SCMPAC
      IF (PEST .EQ. NO) GO TO 1012
      WRITE (6,1180) PSSZ,PSUZ,PSLZ,PSGZ
      WRITE (6,1178) (TIMAP(I),I=1,12),(YEARAP(I),I=1,12),
     1               (SSTR(I),I=1,12)
      WRITE (6,1179) CMAX,DD,K,N,NP
      WRITE (6,1182) (DDG(I),I=1,12),(YDG(I),I=1,12),(KDG(I),I=1,12)
 1012 WRITE (6,1120) HYCAL,INPUT,OUTPUT,PRINT,SNOW,PEST,NUTR,ICHECK
      IF (SNOW.EQ.YES)  WRITE (6,5014) SNOPRT
      IF (PEST.EQ.YES)  WRITE (6,1127) APMODE,DESORP
      WRITE (6,1092)
C
      IF (NUTR .EQ. NO)  GO TO 460
         CALL NUTRIO  (IDERR,INTRVL,NAPPL,SNAPL,UNAPL,TIMHAR,
     1                 INPUT,OUTPUT,APDAY,KNI,KPI,ULUPF,LZUPF)
         IF (IDERR .EQ. 1)  GO TO 1080
C
  460 IF (NUTR .EQ. NO)  GO TO 464
        READ (5,LZTP)
        READ (5,RETP)
C       READ (5,5004)  (LZTEMP(I),I=1,12)
C       READ (5,5002)  ASZT,BSZT,AUZT,BUZT
        WRITE (6,1130)  (LZTEMP(I),I=1,12)
        WRITE (6,1131)  ASZT,BSZT,AUZT,BUZT
  464 IF (PEST.EQ.NO .AND. NUTR.EQ.NO)  GO TO 465
        READ (5,DPTH)
C       READ (5,5010)  SZDPTH,UZDPTH,BDSZ,BDUZ,BDLZ,UZF,LZF
          IF (UZF.EQ.0.0)  UZF = 1.0
          IF (LZF.EQ.0.0)  LZF = 1.0
        WRITE (6,1176)  SZDPTH,UZDPTH,BDSZ,BDUZ,BDLZ,UZF,LZF
        WRITE (6,1181)
C
  465 IF (INPUT .EQ. METR) GO TO 559
      GO TO 449
C
C  CONVERSION OF METRIC INPUT DATA TO ENGLISH UNITS
C
  559 HYMIN= HYMIN*35.3
      UZSN = UZSN/MMPIN
      LZSN = LZSN/MMPIN
      INFIL= INFIL/MMPIN
      L    = L*3.281
      UZS  = UZS/MMPIN
      LZS  = LZS/MMPIN
      SGW  = SGW/MMPIN
      ICS  = ICS/MMPIN
      OFS  = OFS/MMPIN
      IFS  = IFS/MMPIN
      EPXM = EPXM/MMPIN
      SRERI= SRERI/(METOPT*2.471)
      AREA = AREA*2.471
      DO 451 I=1,12
  451    SRERTL(I) = SRERTL(I)/(METOPT*2.471)
C
      IF (SNOW .EQ. NO)  GO TO 403
      ELDIF = ELDIF*3.281
      DGM   = DGM/MMPIN
      MELEV = MELEV*3.281
      TSNOW = 1.8*TSNOW + 32.0
      PACK  = PACK/MMPIN
      DEPTH = DEPTH/MMPIN
      PETMAX= 1.8*PETMAX + 32.0
      PETMIN= 1.8*PETMIN + 32.0
C
  403 IF (PEST .EQ. NO)  GO TO 448
      DO 501 I=1,12
  501     SSTR(I) = SSTR(I)*0.89
      PSSZ = PSSZ*0.89
      PSUZ = PSUZ*0.89
      PSLZ = PSLZ*0.89
      PSGZ = PSGZ*0.89
      ARUDL = ARUDL*25.4
C
  448 IF (NUTR.EQ.NO .AND. PEST.EQ.NO)  GO TO 449
      UZDPTH= UZDPTH/MMPIN
      SZDPTH= SZDPTH/MMPIN
C       28328. = UNIT CONVERSION, CM(3)/FT(3)
      BDSZ = BDSZ*28328./454.
      BDUZ = BDUZ*28328./454.
      BDLZ = BDLZ*28328./454.
C
  449 IERROR = 0
      IF (ICHECK .EQ. OFF) GO TO 452
C
      CALL CHECKR (SSTR,UZDPTH,BDSZ,BDUZ,BDLZ,
     1             CMAX,AREA,HYCAL,INPUT,OUTPUT,PRINT,PEST,
     2             APMODE,DESORP,ENDYR,ENDMON,ENDDAY,
     3             BGNYR,BGNMON,BGNDAY,IERROR,CALB,PROD,
     4             ENGL,METR,BOTH,INTR,HOUR,DAYS,MNTH,YES,NO,
     5             SURF,SOIL,SZDPTH,COVPMO,TIMTIL,TIMAP,
     6             YEARAP,NUTR,LZTEMP)
C
      CALL CHECKS (HYMIN,INTRVL,UZSN,LZSN,IRC,NN,L,SS,A,UZS,LZS,
     1             K24L,KK24,K24EL,K3,SNOW,ICHECK,IERROR,
     2             YES,NO,ON,OFF,RADCON,CCFAC,SCF,ELDIF,
     3             IDNS,F,DGM,WC,EVAPSN,MELEV,TSNOW,
     4             PETMIN,PETMAX,PETMUL,WMUL,RMUL,KUGI)
C
      IF (IERROR .GT. 0) GO TO 1080
C
C                     ADJUSTMENT OF CONSTANTS
C
  452 H = 60/INTRVL
      TIMFAC = INTRVL
      INTRVL = 24*H
      TIMPPT = TIMFAC
      IF (TIMFAC.NE.60) GO TO 4000
      INTRVL = 96
      TIMFAC = 15
      H = 4
C
 4000 KRER = KRER*H**(JRER-1.)
      KSER = KSER*H**(JSER-1.)
C
      M = BDSZ*(SZDPTH/12.0)*43560.*AREA*0.2
      MU = BDUZ*((UZDPTH-SZDPTH)/12.0)
      ML = BDLZ*6.0
      MUZ = MU*43560.*AREA*0.2
      MLZ = ML*43560.*AREA
C
C                                          INITIALIZE TEMP DIST VARIABLES
      TEMPI = 35.
      CHANGE = -12.
      GRAD(1) = 0.04
      GRAD(2) = 0.04
C
      IPACK=0.01
C
      JCOUNT = BGNDAY
      DO 601 I=1,BGNMON
         JCOUNT = JCOUNT + DPMM1(I)
  601 CONTINUE
      IF (MOD(BGNYR,4).EQ.0 .AND. BGNMON.GT.2)  JCOUNT=JCOUNT+1
C
      DO 1005  I=1,5
         SREF(I) = SRERI
         UZSB(I) = UZS
         RESB(I) = UFS
         SRGX(I) = IFS
 1005 CONTINUE
C
      RESS1 = UFS
      RESS = UFS
      SCEP = ICS
      SCEP1 = ICS
      SRGXT = IFS
      SRGXT1 = IFS
      SGW1 = SGW
      COVRMX = 0.0
      DO 1006 I=1,12
 1006    IF (COVRMX.LT.COVPMO(I))  COVRMX=COVPMO(I)
C
      IF (PEST .EQ. NO) GO TO 1007
C
      NI = 1.0/N
      NIP = 1.0/NP
      NCOM = NIP/NI
C
      FP = DD*M
      FPUZ = DD*MUZ
      FPLZ = DD*MLZ
C
C                INITIAL PESTICIDE STORAGES
C
      DO 999 I=1,5
         SSTR1(I) = PSSZ*AREA*0.2
         USTR(I)  = PSUZ*AREA*0.2
  999 CONTINUE
C
      LSTR = PSLZ*AREA
      GSTR = PSGZ*AREA
      SULG = (PSSZ+PSUZ)*AREA + LSTR
      TOTPAP = (PSSZ+PSUZ)*AREA + LSTR + GSTR
C
C                                 PROGRAM EXECUTION
C                                                          BEGIN YEARLY LOOP
 1007 DO 1070  YEAR=BGNYR,ENDYR
         IF (YEAR .EQ. BGNYR) JCOUNT = JCOUNT - 1
         MNSTRT = 1
         MNEND = 12
         IF (YEAR .EQ. BGNYR)  MNSTRT = BGNMON
         IF (YEAR .EQ. ENDYR)  MNEND = ENDMON
C
C
C  EVAP, TEMP(MAX-MIN), RAD, AND WIND  DATA INPUT
C
        DO  1008  DA = 1,31
 1008    READ (5,1264) (IEVAP(MN,DA), MN =1,12)
C
C
        IF (SNOW.EQ.NO .AND. NUTR.EQ.NO)  GO TO 610
         DO  1013 DA = 1,31
 1013    READ(5,1265) ((ITEMP(MN,DA,IT), IT=1,2),MN=1,12)
C
      IF (SNOW .EQ. NO)  GO TO 610
         DO  1014 DA = 1,31
 1014    READ(5,1264) (IWIND(MN,DA), MN=1,12)
```

```
C
      DO 600 DA =1,31
  600 READ (5,1264) (IRAD(MN,DA), MN=1,12)
C
      DO 605 DA=1,31
  605 READ (5,1264) (IDEW(MN,DA), MN=1,12)
C
  610 IF (INPUT .EQ. ENGL) GO TO 625
      DO 700 DA=1,31
         DO 650 MN=1,12
            IEVAP(MN,DA) = IEVAP(MN,DA)*3.937
            IF (SNOW.EQ.YES) IWIND(MN,DA) = IWIND(MN,DA)*0.6214
            IF (SNOW.EQ.YES) IDEW(MN,DA) = 1.8*IDEW(MN,DA) + 32.5
              DO 640 IT=1,2
  640         IF (SNOW.EQ.YES .OR. NUTR.EQ.YES)
     1          ITEMP(MN,DA,IT) = 1.8*ITEMP(MN,DA,IT) + 32.5
  650       CONTINUE
  700    CONTINUE
C                                 SAV TMIN OF JAN 1 ON 11/31
  625 IF (SNOW.EQ.YES .OR. NUTR.EQ.YES) ITEMP(11,31,2) = ITEMP(1,1,2)
C
C
C
C                                                     BEGIN MONTHLY LOOP
       DO 1000  MONTH=MNSTRT,MNEND
C
          COVER1 = COVPMO(MONTH)
          IF (MONTH.LT.12)  COVER2 = COVPMO(MONTH+1)
          IF (MONTH.EQ.12)  COVER2 = COVPMO(1)
          XK31 = K3(MONTH)
          IF (MONTH.LT.12)  XK32 = K3(MONTH+1)
          IF (MONTH.EQ.12)  XK32 = K3(1)
          LTEMP1 = LZTEMP(MONTH)
          LTEMP2 = LZTEMP(1)
          IF (MONTH.NE.12)  LTEMP2=LZTEMP(MONTH+1)
C
          IF (HYCAL .EQ. PROD)  GO TO 1009
          IF (NUTR.EQ.YES)  GO TO 1009
C
          WRITE (6,1263)
          WRITE (6,382)
          WRITE (6,1092)
C
 1009     DYSTRT = 1
C
          DYEND = DPM(MONTH)
          IF (MOD(YEAR,4).EQ.0.AND.MONTH.EQ.2)  DYEND=29
C
          IMDEND=DYEND
          IF (YEAR.EQ.BGNYR .AND. MONTH.EQ.BGNMON)  DYSTRT = BGNDAY
          IF (YEAR.EQ.ENDYR .AND. MONTH.EQ.ENDMON)  DYEND  = ENDDAY
C
C                                                     BEGIN DAILY LOOP
          DO 1050  DAY=DYSTRT,DYEND
             IF ((MONTH .EQ. 1) .AND. (DAY .EQ. 1)) JCOUNT = 0
             IPFLAG = 0
             TIME = 0
             RAINT = 0.0
             EP = PETMUL*IEVAP(MONTH,DAY)/1000.
C
             DO 1019  I=1,INTRVL
                IRAIN(I) = 0
                RAIN(I) = 0.0
 1019        CONTINUE
C
C           CALCULATION OF HOURLY TEMPERATURE FOR SNOW AND/OR NUTRIENTS
C
      IF (SNOW.EQ.NO .AND. NUTR.EQ.NO .AND. PEST.EQ.NO)  GO TO 949
```

```
C
      TMIN = ITEMP(MONTH,DAY,2)
      IF (PACK.LE.0.0 .AND. TMIN.GT.PETMAX .AND. NUTR.EQ.NO
     1 .AND. PEST.EQ.NO)  GO TO 949
C
      IF (YEAR.NE.BGNYR .OR. MONTH.NE.BGNMON .OR.
     1          DAY.NE.BGNDAY) GO TO 899
      CHANGE = (ITEMP(MONTH,DAY,2) - TEMPI)/0.17
  899 TGRAD = 0.0
      DO 948 I=1,24
        IF (I-7)  940, 900, 910
  900   CHANGE = ITEMP(MONTH,DAY,1) - TEMPI
  910   IF (I.NE.17) GO TO 940
C                             IMDEND IS LAST DAY OF PRESENT MONTH
        IF (DAY .NE. IMDEND)  CHANGE =ITEMP(MONTH,DAY+1,2) - TEMPI
        IF (MONTH.NE.12) GO TO 925
        IF (DAY .EQ. IMDEND)  CHANGE = ITEMP(11,31,2) - TEMPI
        GO TO 940
  925   IF (DAY .EQ. IMDEND)  CHANGE = ITEMP(MONTH+1,1,2) - TEMPI
C
  940   IF (ABS(CHANGE).GT.0.001)  GO TO 945
        TGRAD = 0.0
        GO TO 947
  945   TGRAD = GRAD(I)*CHANGE
  947   TEMPX(I) = TEMPI + TGRAD
        TEMPI = TEMPI + TGRAD
  948 CONTINUE
C
C
C           CALCULATE CONTINUOUS WIND AND RAD AND APPLY CORRES MULT
C           FACTORS FOR SNOWMELT CALCULATIONS
C
       IF (SNOW .EQ. NO)  GO TO 949
              WIND = IWIND(MONTH,DAY)
              DEWX = IDEW(MONTH,DAY)
      WINF=(1.0-F) + F*(.35-.03*KUGI)
C                                   WINF REDUCES WIND FOR FORESTED AREAS
C
C             KUGI IS INDEX TO UNDERGROWTH AND FOREST DENSITY,
C             WITH VALUES 0 TO 10 - WIND IN FOREST IS 35% OF
C             WIND IN OPEN WHEN KUGI=0, AND 5% WHEN KUGI=10 -
C             WIND IS ASSUMED MEASURED AT 1-5 FT ABOVE GROUND
C             OR SNOW SURFACE
C
      DEWX = DEWX - 1.0*ELDIF
C                  DEWPT USES A LAPSE RATE OF 1 DEGREE/1000 FT
C
      IF ((PACK .LE. 0.0).AND.(TMIN .GT. PETMAX))  GO TO 949
C
C     CALCULATE HOURLY WIND AND RADIATION
      R = IRAD(MONTH,DAY)
      DO 952 I=1,24
        WINDX(I)  = WMUL*WIND*WINF*WINDIS(I)
        RAD(I)    = RMUL*R*RADCON*RADDIS(I)
  952 CONTINUE
C
C
C        CHECK OF TILLAGE TIME
  949           JCOUNT = JCOUNT + 1
                DO 951 I=1,12
                   IF (JCOUNT.NE.TIMTIL(I) .OR. YEAR.NE.(YRTIL(I)+1900))
     1                GO TO 951
                   WRITE (6,1082)  MNAM(MONTH), DAY, TIMTIL(I), SRERTL(I)
                   DO 950 J=1,5
                      SRER(J) = SRERTL(I)
  950              CONTINUE
  951           CONTINUE
C
```

```
C  CROP CANOPY EFFECTS - ASSUMES LINEAR CHANGE BETWEEN MONTHLY VALUES
C
      COVER = COVER1 + (1.0 - (FLOAT(DPM(MONTH)+1-DAY)/FLOAT(DPM
     1          (MONTH))))*(COVER2-COVER1)
      XK3 = XK31 + (1.0 - (FLOAT(DPM(MONTH)+1-DAY)/FLOAT(DPM(MONTH))))*
     1          (XK32 - XK31)
C
      IF (NUTR.EQ.NO)  GO TO 1017
C
C                             CALCULATION OF HOURLY SOIL TEMPERATURE
C
      IF (INPUT.EQ.ENGL) GO TO 805
      DO 802 JHCUR = 1,24
        TEMPX(JHOUR) = 5./9.*(TEMPX(JHOUR)-31.5)
  802 CONTINUE
C
  805 DO 810  JHOUR=1,24
         STEMP(JHOUR) = ASZT + BSZT*TEMPX(JHOUR)
         UTEMP(JHOUR) =  AUZT + BUZT*STEMP(JHOUR)
  810 CONTINUE
      LTEMP = LTEMP1 + (1.0 - (FLUAT(DPM(MUNTH)+1-DAY)/FLUAT(DPM
     1                    (MUNTH))))*(LTEMP2-LTEMP1)
C
C     CONVERSION OF SOIL TEMP FROM F TO C FOR NUTRNT AND DEGRAD
C
      IF (INPUT .EQ. METR) GO TO 815
      DO 812 JHOUR=1,24
         STEMP(JHOUR) = (STEMP(JHOUR)-32.0)*5./9.
         UTEMP(JHOUR) = (UTEMP(JHOUR)-32.0)*5./9.
  812 CONTINUE
      LTEMP = (LTEMP-32.C)*5./9.
C
C                             NUTRIENT DAILY CALCULATIONS
C
C                             TEST FOR APPLICATION OF FERTILIZERS
C
815   IF (APLCNT .GT. NAPPL)  GO TO 860
      IF (APDAY(APLCNT) .GE. JCOUNT)  GO TO 820
         APLCNT = APLCNT + 1
         GO TU 815
820   IF (JCCUNT .NE. APDAY(APLCNT))  GO TO 860
C
C                             ADD NUTRIENT APPLICATIONS TO STORAGES
C                             AND INCREMENT MASS TOTALS IN SYSTEM
C
      DO 830  IBLK=1,5
         DO 825  J=1,20
            SN(J,IBLK) = SN(J,IBLK) + SNAPL(J,IBLK,APLCNT)
            UN(J,IBLK) = UN(J,IBLK) + UNAPL(J,IBLK,APLCNT)
825      CONTINUE
830   CONTINUE
C
      DO 840  J=1,6
         SUM = C.C
         DO 835  IBLK=1,5
            SUM = SUM + SNAPL(J,IBLK,APLCNT) + UNAPL(J,IBLK,APLCNT)
835      CONTINUE
         TNA = TNA + SUM/5.
840   CONTINUE
      DO 850  J=11,14
         SUM = 0.0
         DO 845  IBLK=1,5
            SUM = SUM + SNAPL(J,IBLK,APLCNT) + UNAPL(J,IBLK,APLCNT)
845      CONTINUE
         TPA = TPA + SUM/5.
850   CONTINUE
      SUM = 0.0
      DO 855  IBLK=1,5
```

```
                SUM = SUM + SNAPL(20,IBLK,APLCNT) + UNAPL(20,IBLK,APLCNT)
      855   CONTINUE
            TCLA = TCLA + SUM/5.
      C
            WRITE (6,4005)  APLCNT, MNAM(MONTH), DAY, JCOUNT
            APLCNT = APLCNT + 1
      C
      860   IF (JCOUNT .NE. TIMHAR)  GO TO 881
      C
      C                          COMPUTE AMOUNT HARVESTED AND DECREASE STORAGES
      C
            DO 870  J=1,20
               TNRHV(J) = 0.0
               IF (SELHV(J) .EQ. 0)  GO TO 870
               SUM = 0.0
               DO 865  IBLK=1,5
                  SUM = SUM + SN(J,IBLK) + UN(J,IBLK)
                  SN(J,IBLK) = 0.0
                  UN(J,IBLK) = 0.0
       865     CONTINUE
               TNRHV(J) = SUM/5. + LN(J) + GN(J)
               LN(J) = 0.0
               GN(J) = 0.0
               TNRHVM(J) = TNRHVM(J) + TNRHV(J)
       870  CONTINUE
            WRITE (6,4006)  MNAM(MONTH), DAY
      C
      C                            TRANSFER INPUT REACTION RATES (KNI,KPI) INTO
      C                            REACTION RATES IN COMMON /NUT/  (KN,KP)
      C                            PLANT UPTAKE RATES ARE THE FRACTION OF THE
      C                            MAXIMUN MONTHLY UPTAKE PER UPPER
      C                            LAYERS,SURFACE AND UPPER ZONE, (ULUPF)
      C                            AND LOWER ZONE (LZUPF).
      C
      881   DO 884  IZONE=1,4
               DO 882  J=1,8
                  KN(J,IZONE) = KNI(J,IZONE)
      882      CONTINUE
               DO 883  J=1,5
                  KP(J,IZONE) = KPI(J,IZONE)
      883      CONTINUE
      884   CONTINUE
      C
            DO 885  IZONE=1,2
               KN(3,IZONE) = KN(3,IZONE)*ULUPF(MONTH)
               KP(3,IZONE) = KP(3,IZONE)*ULUPF(MONTH)
      885   CONTINUE
               KN(3,3) = KN(3,3)*LZUPF(MONTH)
               KP(3,3) = KP(3,3)*LZUPF(MONTH)
      C
      C               CHECK FOR PESTICIDE APPLICATION DATE
      C
       1017 IF (PEST .EQ. NO)  GO TO 1018
            DO 896 I=1,12
               IF (JCOUNT.NE.TIMAP(I) .OR. YEAR.NE.(YEARAP(I)+1900)) GO TO 896
               WRITE (6,1076) MNAM(MONTH),DAY,TIMAP(I),SSTR(I)
               KFLAG = 0
               TOTPAP = TOTPAP + SSTR(I)*AREA
               SULG = SULG + SSTR(I)*AREA
      C
               IF (APMCDE .EQ. SURF)  GO TO 888
               DO 886 J=1,5
                  SSTR1(J) = SSTR1(J) + SSTR(I)*AREA*0.2*(SZDPTH/UZDPTH)
                  USTR(J)  = USTR(J) + SSTR(I)*AREA*0.2 - SSTR1(J)
        886    CONTINUE
               GO TO 896
      C
        888    DO 890 J=1,5
```

```
           SSTR1(J) = SSTR1(J) + SSTR(I)*AREA*0.2
 890     CONTINUE
  896 CONTINUE
C
      IF (SULG .GT. 0.001)  IPFLAG = 1
C
C        CHECK PESTICIDE DEGRADATION RATE
C
      DO 902 I=1,12
         IF (JCOUNT.NE.DDG(I) .OR. YEAR.NE.(YDG(I)+1900)) GO TO 902
         WRITE (6,1077) MNAM(MONTH),DAY,DDG(I),KDG(I)
         DEGCON = KDG(I)
  902 CONTINUE
C
C
C                                PRECIP READ LOOP
C
C
C        CHECK FOR AND READ HOURLY PRECIPITATION
C
 1018 IF (TIMPPT.EQ.5.OR.TIMPPT.EQ.15) GO TO 1020
 2020 DO 2000 J=1,2
         JK = J*720/TIMPPT
         JJ = JK - 720/TIMPPT + 1
         READ(5,2010) YR,MO,DY,CN,(IRAIN(I),I=JJ,JK)
         IF((YR+1900).LT.BGNYR) GO TO 2020
         IF(MO.LT.MNSTRT) GO TO 2020
         IF(DY.LT.DYSTRT) GO TO 2020
         IF (INPUT.EQ.ENGL) GO TO 2030
         DO 2040 I=JJ,JK
 2040       IRAIN(I) = IRAIN(I)*3.937 + 0.5
 2030    JJJ = J
         YR = YR + 1900
         IF (CN.EQ.9) JJJ=CN
         IT = (YEAR-YR) + (MONTH-MO) + (DAY-DY) + (JJJ-CN)
         IF (IT.NE.0) GO TO 1022
         IF (CN.EQ.9) GO TO 1025
 2000 CONTINUE
C
C   HOURLY DATA SPLIT INTO 4 EQUAL 15 MIN DATA ITEMS
C
      DO 2050 J=1,24
         JK= 96 - J*4 + 4
         JJ = 24 - J + 1
         DO 2050 I=1,4
 2050       IRAIN(JK-I+1) = IRAIN(JJ)
      DIV = 400.
      GO TO 1023
C
C        GET 5 OR 15 MINUTE PRECIPITATION DATA
C
 1020 DO 1021 J=1,8
         JK = J*180/TIMFAC
         JJ = JK - 180/TIMFAC + 1
         IF (TIMFAC.EQ.5)  READ (5,1095) YR,MO,DY,CN,(IRAIN(I),I=JJ,JK)
         IF (TIMFAC.EQ.15) READ (5,1094) YR,MO,DY,CN,(IRAIN(I),I=JJ,JK)
         IF((YR+1900).LT.BGNYR) GO TO 1020
         IF(MO.LT.MNSTRT) GO TO 1020
         IF(DY.LT.DYSTRT) GO TO 1020
         IF (INPUT.EQ.ENGL) GO TO 708
         DO 706 I=JJ,JK
            IRAIN(I) = IRAIN(I)*3.937 + 0.5
  706    CONTINUE
  708    JJJ = J
         YR = YR + 1900
         IF (CN.EQ.9) JJJ = 9
         IT = (YEAR-YR) + (MONTH-MO) + (DAY-DY) + (JJJ-CN)
         IF (IT.NE.0) GO TO 1022
      IF (CN.EQ.9) GO TO 1025
 1021 CONTINUE
      DIV = 100.
      GO TO 1023
 1022 WRITE (6,1090) JJJ,MONTH,DAY,YEAR,CN,MO,DY,YR
       GO TO 1080
C
C
 1023           DO 1024  I=1,INTRVL
                   RAIN(I) = IRAIN(I)/DIV
                   RAINT = RAINT + RAIN(I)
 1024              CONTINUE
C
                IF (RAINT.GT.0.0) GO TO 1026
C
C
C  USE RAIN LOOP IF MOISTURE STORAGES ARE NOT EMPTY
C
 1025  IF ((RESS.LT.0.001).AND.(SRGXT.LT.0.001)) GO TO 1040
C
C
C                    RAIN LOOP
C
 1026           DO 1036  I=1,INTRVL
                   TIME = TIME + 1
                   TF = 1
                   PR = RAIN(I)
C
                   IMIN = MOD(TIME,H)
                   IHR = (TIME - IMIN)/H
                   IMIN = TIMFAC*IMIN
                   PRNTKE = 0
                   IF (PRINT.EQ.HOUR) GO TO 1028
                   IF (PRINT.EQ.DAYS) GO TO 1029
                   IF (PRINT.EQ.MNTH) PRNTKE = 2
                   IF (PRINT.EQ.INTR) PRNTKE = 1
                      GO TO 1030
 1028                 IF (IMIN .LT. 1)  PRNTKE = 1
                      GO TO 1030
 1029                 IF (IHR .EQ. 24)  PRNTKE = 1
C
 1030              IF (PRNTKE .NE. 1)  GO TO 1031
C
                   IF (HYCAL .EQ. CALB)  GO TO 1031
C
                   WRITE (6,1101)  IHR, IMIN, DAY,MNAM(MONTH),YEAR
                   WRITE (6,1102)
                   WRITE (6,1103)
C
 1031              CALL LANDS(SFLAG,SNOPRT)
                   IF ((RESS .GE. 0.001).OR.(PR .GT. 0.001))  GO TO 1034
                   DO 1033  J=1,5
                      ERSN(J) = 0.0
 1033                 CONTINUE
                   IF (PRNTKE .EQ. 0)  GO TO 1035
 1034              CALL SEDT(SFLAG)
C
 1035             IF (IPFLAG .EQ. 0)  GO TO 971
                  CALL ADSRB(UZSN,UZF,LZSN,LZF,
     1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     2 APMODE,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     3 DEGLOM,DEGLOT,NIP,NCOM,DIST,TOTPAP,TIMAP,YEARAP,
     4 DESORP,SURF,SOIL,SOLC)
                   IF (IHR .EQ. 24)  GO TO 1038
                    DEGS = 0.0
                    DEGU = 0.0
```

```
                     GO TO 971
      1038           CALL DEGRAD(
     1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     2 APMODE,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     3 DEGLOM,DEGLOT,NIP,NCCM,UIST,TOTPAP,TIMAP,YEARAP,
     4 DESORP,SURF,SOIL,SULG,DEGCON)
       971           IF (NUTR .EQ. NO)  GO TO 1036
C
C
                     CALL NUTRNT(UZSN,UZF,LZSN,LZF)
C
      1036           CONTINUE
C
                  GO TO 1050
C
C                       NO RAIN LOOP
C
C
      1040        TF = INTRVL
                  PR = 0.0
                  P3 = 0.0
                  DO  1042  I=1,5
      1042           RESB1(I) = 0.0
                  PRNTKE = 1
                  IF (PRINT.EQ.MNTH)  PRNTKE = 2
                  IMIN = 00
                  IHR = 24
                  IF (HYCAL.EQ.CALB .OR. PRNTKE.EQ.2)  GO TO 1043
                  WRITE (6,1101)  IHR, IMIN, DAY, MNAM(MONTH), YEAR
                  WRITE (6,1102)
                  WRITE (6,1103)
C
      1043        CALL LANDS(SFLAG,SNOPRT)
                  SRERT = 0.0
                  ERSNT = 0.0
C
                  DO 1041  J=1,5
C                       SOIL COMPACTION -- ONLY ON NON-RAIN DAYS
                     SRER(J) = SRER(J)*(1.0 - SCMPAC)
C
                     SRERT = SRERT + SRER(J)*0.2
                     ERSN(J) = 0.0
      1041        CONTINUE
                  IF (HYCAL.EQ.CALB .OR. PRNTKE.EQ.2)  GO TO 1044
                IF (OUTPUT.EQ. METR) GO TO 1081
                  WRITE (6,1209)
                  WRITE (6,1210) ERSN, ERSNT
                  WRITE (6,1211)  SRER, SRERT
      1081        IF (OUTPUT.EQ. ENGL) GO TO 1044
C  METRIC CONVERSIONS FOR OUTPUT
                  ERSNTT=ERSNT*METOPT*2.471
                  SRRTMT=SRERT*METOPT*2.471
                  DO 1163 I=1,5
                    ERSNMT(I)=ERSN(I)*METOPT*2.471
                    SRERMT(I)=SRER(I)*METOPT*2.471
      1163        CONTINUE
                  WRITE (6,1208)
                  WRITE (6,1210) ERSNMT, ERSNTT
                  WRITE (6,1211) SRERMT, SRRTMT
C
      1044        IF (IPFLAG .EQ. 0)  GO TO 972
                     CALL ADSRB(UZSN,UZF,LZSN,LZF,
     1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     2 APMODE,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     3 DEGLOM,DEGLOT,NIP,NCCM,UIST,TOTPAP,TIMAP,YEARAP,
     4 DESORP,SURF,SOIL,SULG)
                  CALL DEGRAD(
     1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     2 APMODE,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     3 DEGLOM,DEGLOT,NIP,NCOM,UIST,TOTPAP,TIMAP,YEARAP,
     4 DESORP,SURF,SOIL,SULG,DEGCON)
  972       IF (NUTR .EQ. NO)  GO TO 1050
                  CALL NUTRNT(UZSN,UZF,LZSN,LZF)
C                                               END DAILY LOOP
 1050          CONTINUE
C
C                     MONTHLY SUMMARY
C
               CALL OUTMON (YEAR,KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,
     1         GDS,TPBAL,DEGSOM,DEGUOM,DEGLOM,UIST,TOTPAP,TIMAP,YEARAP)
C
C
C                                               END MONTHLY LOOP
 1060       CONTINUE
C
C                    YEARLY SUMMARY
            CALL OUTYR (YEAR,KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     1      TPBAL,DEGSOT,DEGUOT,DEGLOT,UIST,TIMAP,YEARAP)
C
            APLCNT = 1
C                                               END YEARLY LOOP
 1070    CONTINUE
C
C      WRITE REMAINDER OF ARRAYS TO DISK
C
      IF (DISK .EQ. NO)  GO TO 1080
C
      IF(DSNFLO.EQ.0 .OR. NILSRO.EQ.1) GO TO 9990
      IF (OUTPUT .EQ. ENGL)  GO TO 9011
      DO 9010 I=1,TMBLSZ
 9010    LSRO(I) = LSRO(I)*MMPIN
 9011 WRITE(DSNFLO) (LSRO(I),I=1,TMBLSZ)
      IF(IDEBUG .EQ. OFF) GO TO 9990
      WRITE(6,9991) LOOP
 9991 FORMAT('0','DEBUG - - LOOP = ',I5)
      WRITE(6,9992) (LSRO(I),I=1,TMBLSZ)
 9992 FORMAT('0','WRITE TO DISK - LSRO',/,(1X,10(E10.3,2X),/))
C
 9990 IF(DSNERS.EQ.0 .OR. NERDS.EQ.1) GO TO 9080
      IF (OUTPUT .EQ. ENGL)  GO TO 9021
      DO 9020 I=1,TMBLSZ
 9020    EROS(I) = EROS(I)*METOPT*2.471
 9021 WRITE(DSNERS) (EROS(I),I=1,TMBLSZ)
      IF(IDEBUG .EQ. OFF) GO TO 9080
      WRITE(6,9991) LOOP
      CALL EPDBUG(EROS,TMBLSZ)
C
 9080 IF (DSNROS.EQ.0 .OR. NRROS.EQ.1) GO TO 1080
      IF (OUTPUT .EQ. ENGL)  GO TO 9031
      DO 9030 I=1,TMBLSZ
 9030    RROS(I) = RROS(I)*MMPIN
 9031 WRITE(DSNROS) (RROS(I),I=1,TMBLSZ)
      IF (IDEBUG .EQ. OFF)  GO TO 1080
      WRITE (6,9991) LOOP
      CALL EPDBUG(RROS,TMBLSZ)
C
 1080 WRITE (6,1260)
C
C                             FORMAT STATEMENTS
C
 1079 FORMAT ('1','*****ERROR*****  COLS 73-80 SHOULD BE BLANK.',/,1X,
     1    'USER IS ATTEMPTING TO RUN NUMBERED OR WSNAME >72 CHAR',
     2    /,1X,'COLS  73-80 READ',4X,2A4)
 1090 FORMAT ('1','*****ERROR*****  INCORRECT INPUT DATA;   DESIRED ',
     *    'CARD ',I1,' FOR ',I2,'/',I2,'/',I4,'; READ CARD ',I1,' FOR ',
     *   I2,'/',I2,'/',I4)
 1077 FORMAT ('0','BEGINNING ON',1X,A8,1X,I2,2X,'(DOG=',I3,') THE ',
     1                'PESTICIDE DEGRADATION RATE (KDG) EQUALS',F9.3)
 1078 FORMAT ('0','PESTICIDE APPLICATION OCCURS ON',1X,A8,1X,I2,2X,
     1              '(TIMAP=',I3,') WITH AN APPLICATION OF',F6.3,
     2              ' LBS/AC')
 1082 FORMAT ('0','TILLAGE OF THE SOIL OCCURS ON',1X,A8,1X,I2,2X,
     1          '(TIMTIL=',I3,'), RESULTING IN A NEW FINES DEPOSIT ',
     1          'STORAGE OF',F6.3,' TONS/ACRE')
 1083 FORMAT(4X,I2)
 1084 FORMAT('0','***ERROR*** INCORRECT INFORMATION FOR WRITING TO ',
     1          'DISK.',/,1X,'OPTIONS ARE : RUNOFF , SEDIMENT , OVERLAND FL
     2W .',/,1X,'INPUT WAS     ',A8)
 1088 FORMAT('0',/,'0','LINE PRINTER OUTPUT ONLY')
 1085 FORMAT('0',/,'0','DATA TO BE WRITTEN TO DISK AS FOLLOWS: ')
 1086 FORMAT('0','LAND SURFACE RUNOFF/EROSION WRITTEN TO DISK DATASET NU
     1. ',I2)
 1089 FORMAT(1X,'TITLE  -  ',20A4)
 1091 FORMAT ('1',25X,'THIS IS A PRODUCTION RUN')
 1092 FORMAT ('0')
 1093 FORMAT ('1',24X,'THIS IS A CALIBRATION RUN')
 1094 FORMAT (1X,3I2,I1,12I6)
 1095 FORMAT (1X,3I2,I1,36I2)
 2010 FORMAT(10X,3(I2,1X),I1,12I5)
 1096 FORMAT (20A4)
 1097 FORMAT (6X,A4)
 1098 FORMAT (7X,A4)
 1099 FORMAT (5X,A4)
 1100 FORMAT (A8)
 1101 FORMAT ('1',25X,I2,':',I2,'  ON  ',I2,1X,A8,1X,I4)
 1102 FORMAT ('+',25X,'_____________________________' )
 1103 FORMAT ('0',34X,'BLOCK 1   BLOCK 2   BLOCK 3   BLOCK 4   BLOCK 5',
     C  5X,'TOTAL')
 1104 FORMAT ('0',32X,'PESTICIDE APPLICATION:  SURFACE-APPLIED')
 1105 FORMAT ('0',32X,'PESTICIDE APPLICATION:  SOIL-INCORPORATED')
 1106 FORMAT ('0',32X,'CHEMICAL:           ',20A4)
 1107 FORMAT ('0',32X,'WATERSHED:          ',20A4)
 1108 FORMAT ('0',32X,'INPUT UNITS:     ENGLISH')
 1109 FORMAT ('0',32X,'INPUT UNITS:     METRIC')
 1110 FORMAT ('0',32X,'OUTPUT UNITS:    ENGLISH')
 1111 FORMAT ('0',32X,'OUTPUT UNITS:    METRIC')
 1112 FORMAT ('0',32X,'OUTPUT UNITS:    BOTH ENGLISH AND METRIC')
 1113 FORMAT ('0',32X,'PRINT INTERVAL: EACH INTERVAL')
 1114 FORMAT ('0',32X,'PRINT INTERVAL: EACH HOUR')
 1115 FORMAT ('0',32X,'PRINT INTERVAL: EACH DAY')
 1128 FORMAT ('0',32X,'PRINT INTERVAL: EACH MONTH')
 1116 FORMAT ('0',32X,'SNOWMELT CALCULATIONS PERFORMED')
 1117 FORMAT ('0',32X,'SNOWMELT NOT PERFORMED')
 1118 FORMAT ('0',32X,'ADSORPTION AND DESORPTION ALGORITHMS USED')
 1119 FORMAT ('0',32X,'ADSORPTION CALCULATED ONLY, NO DESORPTION')
 1120 FORMAT ('0',/'0','HYCAL=',A4,2X,'INPUT=',A4,2X,'OUTPUT=',A4,2X,
     1'PRINT=',A4,2X,'SNOW=',A4,2X,'PEST=',A4,2X,'NUTR=',A4,2X,
     2'ICHECK=',A4)
 1121 FORMAT ('0','INPUT ERROR: IT IS NOT POSSIBLE TO MAKE CALIBRATION R
     1UN WITH BOTH PESTICIDES AND NUTRIENTS TOGETHER',/,' ','CHANGE HYCA
     2L TO PROD, OR EITHER PEST OR NUTR FROM YES TO NO')
 1122 FORMAT ('0','INPUT ERROR: THE FIRST LINE OF THE PESTICIDE INPUT SE
     1QUENCE MUST BE THE WORD PESTICIDE, CORRECT AND RUN AGAIN')
 1123 FORMAT ('+',50X,'FOR PESTICIDES')
 1124 FORMAT ('+',50X,'FOR NUTRIENTS')
 1125 FORMAT ('+',50X,'FOR HYDROLOGY AND SEDIMENT ONLY')
 1126 FORMAT ('+',50X,'FOR PESTICIDES AND NUTRIENTS')
 1127 FORMAT ('0','APMODE=',A4,2X,'DESORP=',A4)
 1130 FORMAT ('0','LOWER ZONE MONTHLY SOIL TEMPERATURES =  ', 12F6.1)
 1131 FORMAT ('0','SOIL TEMPERATURE REGRESSION EQUATION CONSTANTS',
     1/,' ','SURFACE ZONE:  ASZT = ',F8.3,4X,'BSZT= ',F8.3,
     2/,' ','UPPER ZONE:    AUZT = ',F8.3,4X,'BUZT= ',F8.3)
 1164 FORMAT ('0','INTRVL= ',I2,13X,'HYMIN= ',F8.4,8X,'AREA= ',F10.4)
 1165 FORMAT ('0','BGNDAY= ',I2,13X,'BGNMON= ',I2,13X,'BGNYR= ',I4)
 1166 FORMAT ('0','ENDDAY= ',I2,13X,'ENDMON= ',I2,13X,'ENDYR= ',I4)
 1167 FORMAT ('0',/'0','UZSN= ',F8.4,9X,'UZS= ',F8.4,10X,'LZSN= ',F8.4,
     19X,'LZS= ',F8.4)
 1168 FORMAT ('0','L= ',F8.4,12X,'SS= ',F8.4,11X,'NN= ',F8.4,11X,'A= ',
     1F8.4,12X,'EPXM= ',F8.4,9X,'PETMUL=',F8.4)
  1162 FORMAT('0','K3 = ',12(F4.2,2X))
 1169 FORMAT ('0','INFIL= ',F8.4,8X,'INTER= ',F8.4,8X,'IRC= ',F8.4,10X,
     1'K24L= ',F8.4,9X,'KK24= ',F8.4,9X,'K24EL= ',F8.4)
 1170 FORMAT ('0','SGW= ',F8.4,10X,'GWS= ',F8.4,10X,'KV= ',F8.4,11X,
     1'ICS= ',F8.4,10X,'CFS= ',F8.4,10X,'IFS= ',F8.4)
 1171 FORMAT ('0',/'0','RADCON= ',F8.4,7X,'CCFAC= ',F8.4,8X,'SCF= ',
     1F8.4,10X,'ELDIF= ',F8.4,8X,'IDNS= ',F8.4,9X,'F= ',F8.4)
 1172 FORMAT ('0','DGM= ',F8.4,10X,'WC= ',F8.4,11X,'MPACK= ',F8.4,8X,
     1'EVAPSN= ',F8.4,7X,'MELEV= ',F8.0,8X,'TSNOW= ',F8.4)
 1173 FORMAT ('0','PACK= ',F8.4,9X,'DEPTH= ',F8.4)
 1174 FORMAT ('0','PETMIN= ',F8.4,7X,'PETMAX= ',F8.4,
     17X,'WMUL= ',F8.4,9X,'RMUL= ',F8.4,9X,'KUGI= ',F8.4)
 1175 FORMAT ('0',/'0','COVPMO= ', 12(F4.2,2X) )
 1176 FORMAT ('0','SOIL ZONES DEPTHS AND BULK DENSITIES',/,' ',
     1'SZDPTH= ',F8.4,7X,'UZDPTH= ',F8.4,7X,'BDSZ= ',F8.4,7X,
     2'BDUZ= ',F8.4,7X,'BDLZ= ',F8.4,/,'0','LEACHING FACTORS',
     3/,' ','UZF = ',F6.3,7X,'LZF = ',F6.3)
 1177 FORMAT ('0','JRER= ',F6.4,9X,'KRER= ',F6.4,9X,'JSER= ',F6.4,9X,
     1'KSER= ',F6.4,9X,'SRERI= ',F6.4,9X,'SCMPAC= ',F6.4)
 1178 FORMAT ('0','TIMAP=  ',12(I3,2X),/,1X,
     1                    'YEARAP= ',12(I3,2X),/,1X,
     2                    'SSTR=   ',12(F6.3,2X))
 1180 FORMAT ('0',/'0','PSSZ= ',F8.4,9X,'PSUZ=',F8.4,9X,'PSLZ=',F8.4,9X,
     1             'PSGZ= ',F8.4)
 1179 FORMAT ('0','CMAX= ',F8.6,9X,'DD= ',F8.6,11X,
     1'K= ',F8.4,12X,'N= ',F8.4,12X,'NP= ',F8.4)
 1181   FORMAT('1')
 1182 FORMAT ('0','DDG= ',12(I3,2X),/,1X,'YDG= ',12(I3,2X),/,1X,'KDG= ',
     1                       12(F5.3,2X))
 1183 FORMAT ('0','TIMTIL= ',12(I3,2X),/,1X,
     1             'YRTIL = ',12(I2,3X),/,1X,
     1             'SRERTL= ',12(F6.3,2X))
  382 FORMAT (' ',87X,'WATER',24X,'SEDIMENT')
  1208 FORMAT ('0',8X,'SEDIMENT,TONNES/HECTARE')
  1209 FORMAT ('0', 8X,'SEDIMENT, TONS/ACRE')
  1210 FORMAT (' ',11X,'ERODED SEDIMENT    ',5(3X,F7.3),4X,F7.3)
  1211 FORMAT (' ',11X,'FINES DEPOSIT',6X,5(3X,F7.3),4X,F7.3)
  1260 FORMAT ('1','END OF SIMULATION')
  1263 FORMAT ('1',5X,'DATE',4X,'TIME',4X,'FLOW(CFS-CMS)',6X,
     X          'SEDIMENT (LBS-KG-KG/MIN-GM/L)',23X,
     X          'PESTICIDE (GM-GM/MIN-PPM)')
  1265 FORMAT (8X,24I3)
  1264 FORMAT (8X,12I6)
 4005  FORMAT  ('0','NUTRIENT APPLICATION NO. ',I2,' OCCURS ON ',
     1           A8,2X,I2,'  (DAY = ',I3,')' )
 4006  FORMAT  ('0','PLANT HARVESTING OCCURS ON ',A8,1X,I2)
 5000  FORMAT (8X,I2,2(8X,F6.0))
 5001  FORMAT (2(8X,I2),8X,I4)
 5002  FORMAT (4(8X,F6.0))
 5003  FORMAT (6(8X,F6.0))
 5004  FORMAT (8X,12F6.0)
 5005  FORMAT (2(8X,F6.0))
 5006  FORMAT (5(8X,F6.0))
 5009  FORMAT (8X,12I4)
 5010  FORMAT (2(8X,F6.0),3(8X,F6.0),2(4X,F4.0))
 5012  FORMAT (3(8X,F6.0))
  9956 FORMAT ('0','DEBUG OPTION IS ON')
  5013 FORMAT (10X,A4)
  5014 FORMAT ('0','SNOWPRINT=',A4)
C
       STOP
```

```
      END
      SUBROUTINE ERRSET(RESULT)
      REAL RESULT
      RESULT=0.0
      RETURN
      END
C
C
C
C
      SUBROUTINE CHECKR (SSTR,UZDPTH,BDSZ,BDUZ,BDLZ,
     1                   CMAX,AREA,HYCAL,INPUT,OUTPUT,PRINT,PEST,
     2                   APMODE,DESORP,ENDYR,ENDMON.ENDDAY,
     3                   BGNYR,BGNMON,BGNDAY,IERROR,CALB,PROD,
     4                   ENGL,METR,BOTH,INTR,HOUR,DAYS,MNTH,YES,NO,
     5                   SURF,SOIL,SZDPTH,COVPMO,TIMTIL,TIMAP,
     6                   YEARAP,NUTR,LZTEMP)
C
      DIMENSION  SSTR(12),COVPMO(12),TIMTIL(12),LZTEMP(12)
C
      REAL  LZTEMP
      REAL  SSTR,UZDPTH,BDSZ,BDUZ,BDLZ,CMAX,AREA,SZDPTH,COVPMO
C
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT PROD,SNOW,YES
C
      INTEGER*4  APMODE,DESORP,SURF,SOIL
      INTEGER  ENDYR,ENDMON,ENDDAY,BGNYR,BGNMON,BGNDAY
C
      INTEGER  TIMTIL,TIMAP(12),YEARAP(12)
C
 1513 IF (UZDPTH .GT. SZDPTH) GO TO 1514
           WRITE (6,1613)
           IERROR = IERROR + 1
 1514 IF (SZDPTH .LT. 1.0) GO TO 1515
           WRITE (6,1614) SZDPTH
           IERROR= IERROR + 1
 1515 DO 1516 I=1,12
      IF (COVPMO(I) .LE. 1.0) GO TO 1516
           WRITE (6,1615) COVPMO(I)
           IERROR= IERROR + 1
 1516 CONTINUE
      DO 1526 I=1,12
      IF (TIMTIL(I) .GE. 0 .AND. TIMTIL(I) .LT. 367) GO TO 1526
           WRITE (6,1617) TIMTIL(I)
           IERROR= IERROR + 1
 1526 CONTINUE
 1518 IF (BDSZ.GT.31.2 .OR. BDUZ.GT.31.2 .OR. BDLZ.GT.31.2) GO TO 1519
           WRITE (6,1618)  BDSZ,BDUZ,BDLZ
           IERROR = IERROR + 1
 1519 IF (AREA .GT. 0.01) GO TO 1520
           WRITE (6,1619)  AREA
           IERROR = IERROR + 1
 1520 IF (HYCAL .EQ. CALB .OR. HYCAL .EQ. PROD)  GO TO 1521
           WRITE (6,1620)  HYCAL
           IERROR = IERROR + 1
 1521 IF (INPUT .EQ. ENGL .OR. INPUT .EQ. METR) GO TO 1522
           WRITE (6,1621)  INPUT
           IERROR = IERROR + 1
 1522 IF (OUTPUT .EQ. ENGL .OR. OUTPUT .EQ. METR .OR. OUTPUT .EQ. BOTH)
     1     GO TO 1523
           WRITE (6,1622)  OUTPUT
           IERROR = IERROR + 1
 1523 IF (PRINT .EQ. INTR .OR. PRINT .EQ. HOUR .OR. PRINT .EQ. DAYS
     1     .OR. PRINT .EQ. MNTH) GO TO 1550
           WRITE (6,1623)  PRINT
           IERROR = IERROR + 1
 1550 IF (PEST .EQ. YES .OR. PEST .EQ. NO) GO TO 1551
```

Reproduced from
best available copy.

```
          WRITE (6,1650) PEST
          IERROR= IERROR + 1
 1551 IF (PEST .EQ. NO)  GO TO 1565
      IF (APMODE .EQ. SURF .OR. APMODE .EQ. SOIL) GO TO 1553
          WRITE (6,1652)  APMODE
          IERROR = IERROR + 1
 1553 IF (DESORP .EQ. YES .OR. DESORP .EQ. NO) GO TO 1554
          WRITE (6,1653)  DESORP
          IERROR = IERROR + 1
 1554 DO 1555 I=1,12
      IF (SSTR(I) .GE. 0.0) GO TO 1555
          WRITE (6,1654)
          IERROR = IERROR + 1
 1555 CONTINUE
      IF (CMAX .LE. 1.0) GO TO 1556
          WRITE (6,1656)  CMAX
          IERROR = IERROR + 1
 1556 DO 1558 I=1,12
         IF (TIMAP(I).GE.0 .AND. TIMAP(I).LT.367)  GO TO 1557
         WRITE (6,1657) TIMAP(I)
         IERROR = IERROR + 1
 1557    IF ((YEARAP(I)+1900).GE.BGNYR .AND. (YEARAP(I)+1900).LE.
     1         ENDYR)  GO TO 1558
         WRITE (6,1658)
         IERROR = IERROR + 1
 1558 CONTINUE
 1565 IF (NUTR .EQ. YES .OR. NUTR .EQ. NO) GO TO 1570
          WRITE (6,1665) NUTR
          IERROR= IERROR + 1
 1570 IF (NUTR.EQ.NO .AND. PEST.EQ.NO)  GO TO 1581
      DO 1572 I=1,12
         IF (LZTEMP(I).GT.-10.0 .AND. LZTEMP(I).LT.120.0) GO TO 1572
         WRITE (6,1670) LZTEMP(I)
         IERROR = IERROR + 1
 1572 CONTINUE
 1581 IF (ENDYR .GT. BGNYR) GO TO 1582
      IF (ENDYR .EQ. BGNYR .AND. ENDMON .GT. BGNMON) GO TO 1582
      IF (ENDYR .EQ. BGNYR .AND. ENDMON .EQ. BGNMON .AND. ENDDAY
     1         .GE. BGNDAY) GO TO 1582
          WRITE (6,1681)
          IERROR = IERROR + 1
 1582 CONTINUE
C
C CHECKR ERROR STATEMENTS
C
 1613 FORMAT ('0','ERROR: UZDPTH HAS BEEN INPUTTED LESS THAN OR EQUAL TO
     1 SZDPTH; THIS IS NOT REALISTIC')
 1614 FORMAT ('0','ERROR: SZDPTH HAS BEEN INPUTTED AS ',F8.4,'; IT MUST
     1BE LESS THAN 1.0 INCHES')
 1615 FORMAT ('0','ERROR: ONE OF THE VALUES FOR COVPMO HAS BEEN INPUTTED
     1 AS ',F8.4,'; COVPMO MUST BE LESS THAN 1.0')
 1617 FORMAT ('0','ERROR: ONE OF THE VALUES FOR TIMTIL HAS BEEN INPUTTED
     1 AS ',I8,'; TIMTIL MUST BE A POSITIVE INTEGER LESS THAN 367')
 1618 FORMAT ('0','ERROR: BCSZ, BDUZ, AND BDLZ  HAS BEEN INPUTTED AS ',
     13F8.4,'; THEY MUST BE GREATER THAN 31.2 LB/FT(3)')
 1619 FORMAT ('0','ERROR: AREA HAS BEEN INPUTTED AS ',F8.6,'; IT SHOULD
     1BE INPUTTED IN ACRES, HOWEVER IF THIS IS ACTUALLY THE CASE THEN SE
     2T ICHECK=OFF',/,' ','AND RUN AGAIN')
 1620 FORMAT ('0','ERROR: HYCAL HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
     1SET EQUAL TO CALB OR PROD')
 1621 FORMAT ('0','ERROR: INPUT HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
     1SET EQUAL TO ENGL OR METR')
 1622 FORMAT ('0','ERROR: OUTPUT HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
     1 SET EQUAL TO EITHER ENGL, METR, OR BOTH')
 1623 FORMAT ('0','ERROR: PRINT HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
     1SET EQUAL TO EITHER INTR, HOUR, DAYS, OR MNTH')
 1650 FORMAT ('0','ERROR: PEST HAS BEEN INPUTTED AS ',A4,'; IT MUST BE S
     1ET EQUAL TO YES OR NO')
 1652 FORMAT ('0','ERROR: APMODE HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
     1 SET EQUAL TO SURF OR SOIL')
 1653 FORMAT ('0','ERROR: DESUFP HAS BEEN INPUTTED AS ',A4,'; IT MUST BE
     1 SET EQUAL TO YES OR NO')
 1654 FORMAT ('0','ERROR: SOME OF THE 12 SSTR VALUES INPUTTED ARE LESS T
     1HAN 0.0; THEY MUST BE POSITIVE')
 1656 FORMAT ('0','ERROR: CMAX HAS BEEN INPUTTED AS ',F8.4,'; IT SHOULD
     1BE SET LESS THAN OR EQUAL TO 1.0')
 1657 FORMAT ('0','ERROR: TIMAP HAS BEEN INPUTTED AS ',I4,'; TIMAP MUST
     1BE A POSITIVE INTEGER LESS THAN 367')
 1658 FORMAT ('0','ERROR: THE INPUTTED YEAR OF APPLICATION DOES NOT OCCU
     1R WITHIN THE PERIOD OF SIMULATION')
 1665 FORMAT ('0','ERROR: NUTR HAS BEEN INPUTTED AS ',A4,'; IT MUST BE S
     1ET EQUAL TO YES OR NO')
 1670 FORMAT ('0','ERROR: ONE OF THE VALUES OF LZTEMP HAS BEEN INPUTTED
     1AS ',F8.4,'; THIS IS NOT REALISTIC, CHECK INPUT UNIT CONSISTENCY')
 1681 FORMAT ('0','ERROR: THE INPUTTED END DATE (ENDDAY,ENDMON,ENDYR) OC
     1CURS BEFORE THE BEGIN DATE (BGNDAY,BGNMON,BGNYR)')
C
      RETURN
      END
C
C
C
C
      SUBROUTINE CHECKS (HYMIN,INTRVL,UZSN,LZSN,IRC,NN,L,SS,A,UZS,LZS,
     1                   K24L,KK24,K24EL,K3,SNOW,ICHECK,IERROR,
     2                   YES,NO,ON,OFF,RADCON,CCFAC,SCF,ELDIF,
     3                   IDNS,F,DGM,WC,EVAPSN,MELEV,TSNOW,
     4                   PETMIN,PETMAX,PETMUL,WMUL,RMUL,KUGI)
C
      DIMENSION  K3(12)
C
      REAL LZSN,IRC,NN,L,LZS,K24L,KK24,K24EL,K3
      REAL  IDNS,MELEV,KUGI
      REAL  HYMIN,UZSN,SS,A,UZS,RADCON,CCFAC,SCF,ELDIF,F,DGM,WC,
     1       EVAPSN,TSNOW,PETMIN,PETMAX,PETMUL,WMUL,RMUL
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
C
      INTEGER*4  ICHECK
C
      IF (HYMIN .GT. 0.0) GO TO 1501
           WRITE (6,1600)  HYMIN
           IERROR = IERROR + 1
 1501 IF (INTRVL.EQ.5 .OR. INTRVL.EQ.15 .OR. INTRVL.EQ.60) GO TO 1502
           WRITE (6,1601)  INTRVL
           IERROR = IERROR + 1
 1502 IF (UZSN .LT. LZSN) GO TO 1503
           WRITE (6,1602)
           IERROR = IERROR + 1
 1503 IF (IRC .LE. 1.0) GO TO 1504
           WRITE (6,1603)  IRC
           IERROR = IERROR + 1
 1504 IF (NN .LE. 1.0) GO TO 1505
           WRITE (6,1604)  NN
           IERROR = IERROR + 1
 1505 IF (L .GT. 1.0) GO TO 1506
           WRITE (6,1605)  L
           IERROR = IERROR + 1
 1506 IF (SS .LT. 1.0) GO TO 1507
           WRITE (6,1606)  SS
           IERROR = IERROR + 1
 1507 IF (A .LE. 0.0) GO TO 1508
           WRITE (6,1607)  A
           IERROR = IERROR + 1
 1508 IF (UZS .LT. LZS) GO TO 1509
           WRITE (6,1608)
```

Reproduced from
best available copy.

```
           IERROR = IERROR + 1
      1509 IF (K24L .LE. 1.0) GO TO 1510
           WRITE (6,1609)  K24L
           IERROR = IERROR + 1
      1510 IF (KK24 .LE. 1.0) GO TO 1511
           WRITE (6,1610)  KK24
           IERROR = IERROR + 1
      1511 IF (K24EL .LE. 1.0) GO TO 1512
           WRITE (6,1611)  K24EL
           IERROR = IERROR + 1
      1512 DO 1527 I=1,12
        IF (K3(I) .LE. 1.0) GO TO 1527
           WRITE (6,1612)  K3(I)
           IERROR = IERROR + 1
      1527 CONTINUE
      1524 IF (SNOW .EQ. YES .OR. SNOW .EQ. NO) GO TO 1525
           WRITE (6,1624)  SNOW
           IERROR = IERROR + 1
      1525 IF (SNOW .EQ. NO) GO TO 1550
        IF (RADCON .GT. 0.0) GO TO 1529
           WRITE (6,1628) RADCON
           IERROR= IERROR + 1
      1529 IF (CCFAC .GT. 0.0) GO TO 1530
           WRITE (6,1629) CCFAC
           IERROR= IERROR + 1
      1530 IF (SCF .GT. 0.0) GO TO 1531
           WRITE (6,1630) SCF
           IERROR= IERROR + 1
      1531 IF (ELDIF .LT. 30.0) GO TO 1532
           WRITE (6,1631) ELDIF
           IERROR= IERROR + 1
      1532 IF (IDNS .LT. 1.0) GO TO 1533
           WRITE (6,1632) IDNS
           IERROR= IERROR + 1
      1533 IF (F .LE.  1.0) GO TO 1534
           WRITE (6,1633) F
           IERROR= IERROR + 1
      1534 IF (DGM .LT. 1.0) GO TO 1535
           WRITE (6,1634) DGM
           IERROR= IERROR + 1
      1535 IF (WC .LT. 1.0) GO TO 1536
           WRITE (6,1635) WC
           IERROR= IERROR + 1
      1536 IF (EVAPSN .GT. 0.0) GO TO 1537
           WRITE (6,1636) EVAPSN
           IERROR= IERROR + 1
      1537 IF (MELEV .LT. 30000.0) GO TO 1538
           WRITE (6,1637) MELEV
           IERROR= IERROR + 1
      1538 IF (TSNOW .GT. 20.0 .AND. TSNOW .LT. 40.0) GO TO 1539
           WRITE (6,1638) TSNOW
           IERROR= IERROR + 1
      1539 IF (PETMIN .GT. 30.0) GO TO 1540
           WRITE (6,1639) PETMIN
           IERROR= IERROR + 1
      1540 IF (PETMAX .LT. 65.0) GO TO 1542
           WRITE (6,1640) PETMAX
           IERROR= IERROR + 1
      1542 IF (WMUL .GT. 0.0) GO TO 1543
           WRITE (6,1642) WMUL
           IERROR= IERROR + 1
      1543 IF (RMUL .GT. 0.0) GO TO 1544
           WRITE (6,1643) RMUL
           IERROR= IERROR + 1
      1544 IF (KUGI .GE. 0.0 .AND. KUGI .LE. 10.0) GO TO 1550
           WRITE (6,1644) KUGI
           IERROR= IERROR + 1
```

```
 1550 IF (PETMUL .GT. 0.0) GO TO 1580
            WRITE (6,1641) PETMUL
            IERROR= IERROR + 1
 1580 IF (ICHECK .EQ. ON) GO TO 1582
            WRITE (6,1680)  ICHECK
            IERROR = IERROR + 1
 1582 IF (IERROR .GT. 0) WRITE (6,1682) IERROR
C
C CHECKS ERROR STATEMENTS
C
 1600 FORMAT ('0','ERROR: HYMIN HAS BEEN INPUTTED AS ',F8.4,'; IT MUST B
     1E SET GREATER THAN 0.0')
 1601 FORMAT ('0','ERROR: INTRVL HAS BEEN INPUTTED AS ',I4,'; IT MUST BE
     1 SET EQUAL TO EITHER 5, 15 OR 60 MINUTES')
 1602 FORMAT ('0','ERROR: UZSN HAS BEEN INPUTTED GREATER THAN OR EQUAL T
     1O LZSN, THIS IS NOT REALISTIC')
 1603 FORMAT ('0','ERROR: IRC HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE
     1SET LESS THAN OR EQUAL TO 1.0')
 1604 FORMAT ('0','ERROR: NN HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE S
     1ET LESS THAN 1.0')
 1605 FORMAT ('0','ERROR: L HAS BEEN INPUTTED AS ',F8.4,'; THIS LOOKS RA
     1THER STRANGE - REMEMBER THE UNITS ARE IN FEET OR METERS')
 1606 FORMAT ('0','WARNING: SS HAS BEEN INPUTTED AS ',F8.4,'; A LAND SLO
     1PE OF 45 DEGREES OR GREATER IS QUESTIONABLE, HOWEVER IF THIS ACTUA
     2LLY IS TRUE',/,' ','SET ICHECK=OFF AND RUN AGAIN')
 1607 FORMAT ('0','WARNING: A HAS BEEN INPUTTED AS ',F8.4,': IMPERVIOUS
     1AREA IS NOT CONSIDERED IN SEDIMENT REMOVAL AS THE MODEL IS BASICAL
     2LY FOR ',/,' ','AGRICULTURAL AREAS, HOWEVER IF IMPERVIOUS AREA IS
     3DESIRED SET ICHECK=OFF AND RUN AGAIN')
 1608 FORMAT ('0','ERROR: UZS HAS BEEN INPUTTED GREATER THAN OR EQUAL TO
     1 LZS, THIS IS NOT REALISTIC')
 1609 FORMAT ('0','ERROR: K24L HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE
     1 SET LESS THAN OR EQUAL TO 1.0')
 1610 FORMAT ('0','ERROR: KK24 HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE
     1 SET LESS THAN OR EQUAL TO 1.0')
 1611 FORMAT ('0','ERROR: K24EL HAS BEEN INPUTTED AS ',F8.4,'; IT MUST B
     1E SET LESS THAN OR EQUAL TO 1.0')
 1612 FORMAT ('0','ERROR: K3 HAS BEEN INPUTTED AS ',F8.4,'; IT MUST BE S
     1ET LESS THAN OR EQUAL TO 1.0')
 1624 FORMAT ('0','ERROR: SNOW HAS BEEN INPUTTED AS ',A4,'; IT MUST BE S
     1ET EQUAL TO YES OR NO')
 1628 FORMAT ('0','ERROR: RADCON HAS BEEN INPUTTED AS ',F8.4,'; RADCON M
     1UST BE GREATER THAN 1.0')
 1629 FORMAT ('0','ERROR: CCFAC HAS BEEN INPUTTED AS ',F8.4,'; CCFAC MUS
     1T BE GREATER THAN 0.0')
 1630 FORMAT ('0','ERROR: SCF HAS BEEN INPUTTED AS ',F8.4,'; SCF MUST BE
     1 GREATER THAN 0.0')
 1631 FORMAT ('0','ERROR: ELDIF HAS BEEN INPUTTED AS ',F8.4,'; ELDIF SHO
     1ULD BE INPUT IN THOUSANDS OF FEET AND CANNOT EXCEED 30.0')
 1632 FORMAT ('0','ERROR: IONS HAS BEEN INPUTTED AS ',F8.4,'; IONS MUST
     1BE LESS THAN 1.0')
 1633 FORMAT ('0','ERROR: F HAS BEEN INPUTTED AS ',F8.4,'; F MUST BE LES
     1S THAN OR EQUAL TO 1.0')
 1634 FORMAT ('0','WARNING: DGM HAS BEEN INPUTTED AS ',F8.4,'; VALUES GR
     1EATER THAN 1.0 INCHES FOR DGM ARE QUESTIONABLE')
 1635 FORMAT ('0','ERROR: WC HAS BEEN INPUTTED AS ',F8.4,'; WC MUST BE L
     1ESS THAN 1.0')
 1636 FORMAT ('0','ERROR: EVAPSN HAS BEEN INPUTTED AS ',F8.4,'; EVAPSN C
     1ANNOT BE A NEGATIVE NUMBER')
 1637 FORMAT ('0','ERROR: MELEV HAS BEEN INPUTTED AS ',F9.1,'; MELEV CAN
     1NOT HAVE A VALLE GREATER THAN 30000.0')
 1638 FORMAT ('0', 'ERROR: TSNOW HAS BEEN INPUTTED AS ',F8.4,'; TSNOW MU
     1ST HAVE A VALUE GREATER THAN 20.0 AND LESS THAN 40.0')
 1639 FORMAT ('0','ERROR: PETMIN HAS BEEN INPUTTED AS ',F8.4,'; PETMIN M
     1UST BE GREATER THAN 30.0')
 1640 FORMAT ('0','ERROR: PETMAX HAS BEEN INPUTTED AS ',F8.4,'; PETMAX M
     1UST BE LESS THAN 80.0')
 1641 FORMAT ('0','ERROR: PETMUL HAS BEEN INPUTTED AS ',F8.4,'; PETMUL M
     1UST BE GREATER THAN 0.0')
 1642 FORMAT ('0','ERROR: WMUL HAS BEEN INPUTTED AS ',F8.4,': WMUL MUST
     1BE GREATER THAN 0.0')
 1643 FORMAT ('0','ERROR: RMUL HAS BEEN INPUTTED AS ',F8.4,': RMUL MUST
     1BE GREATER THAN 0.0')
 1644 FORMAT ('0','ERROR: KUGI HAS BEEN INPUTTED AS ',F8.4,': KUGI MUST
     1BE A POSITIVE NUMBER LESS THAN 10.0')
 1680 FORMAT ('0','ERROR: ICHECK HAS BEEN INPUTTED AS ',A4,': IT MUST BE
     1 SET EQUAL TO ON OR OFF')
 1682 FORMAT ('0','THE TOTAL NUMBER OF DETECTED ERRORS IN THE INPUT SEQU
     1ENCE EQUALS',I3,', PLEASE CORRECT AND TRY AGAIN OR CONTACT EPA')
C
      RETURN
      END
C
C
C
C
      BLOCK DATA
C
C
C                    BLOCK DATA TO INITIALIZE VARIABLES
C
C
      IMPLICIT  REAL(L)
C
      DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
     1 UZSB(5),APERCB(5),RIB(5),ERSN(5),K3(12)
      DIMENSION SRER(5),ROBTOM(5),ROBTOT(5),INFTOM(5),INFTOT(5),
     1 ROITOM(5),ROITOT(5),RXB(5),ERSTOM(5),ERSTOT(5),MNAM(12),RAD(24),
     2 TEMPX(24),WINDX(24),RAIN(288)
      DIMENSION LSRO(128),EROS(128),RROS(128)
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1          STEMP(24),UTEMP(24)
C
      COMMON /ALL/ RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
     2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
     3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
     4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
     1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
     2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
     4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
     5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
     6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
     7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
     8 MELRAM,RADMEM,CONMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
     9 PXSNY,MELRAY,RADMEY,CONMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
     * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
     1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
     2 DSNFLO,DSNERS,LSRO,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
C
      COMMON /NUT/  DFLT,SN,SNT,SNRSM,SNRUM,UN,UNT,UNI,UNIT,
     1             UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2             SNRSY,SNRCY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3             TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4             KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5             TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      COMMON /PESTO/
     1 STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
     4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
C
```

```
C   COMMON ALL DECLARATIONS FOR I*2 & R*4
      INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
     REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
    1      UZSB,APERCB,KIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
    2      LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
C   COMMON LAND DECLARATIONS FOR I*2 & R*4
      INTEGER  DAY,MONTH,DSNROS,DSNFLO,DSNERS,TMBLSZ,NEROS,
    1          NILSRC,NKROS
     REAL  SEVAPM,SUMSNY,PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,
    1      CRAINY,SNEGMY,SEVAPY,TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,
    2      RXB,ROITOM,PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,
    3      IPACK,TMIN,SUMSNM,PXSNM,XK3,MELRAM,RADMEM,CORMEM,CRAINM,
    4      CONMEM,SGMM,SNEGMM,PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,
    5      NEPTOM,RCSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,NEPTOT,
    6      ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
    7      UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,
    8      KV,K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,
    9      SCEP1,SRGXT,SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,
    *      METOPT,CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,
    1      TSNOW,PETMIN,ROITOT,INFTOM,INFTOT,ERSTOM,ERSTOT,SRER,
    2      TEMPX,RAD,WINDX,RAIN,LSRO,EROS,RROS
C
C
      INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
    1            MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
      INTEGER*4  LOOP
       DOUBLE PRECISION  MNAM
      REAL  NP
C
      REAL  DELT,
    1         SNT(20),SNRSM(20,5),SNROM(20,5),
    2         UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
    3         NRSM(20,5),LNRPM(20),
    4         SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
    5         SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
    6         LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
    7         TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
    8         KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
      DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
      REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
    2 PROTOT(5),SCST,UPITOM(5),SOST,UPITOT(5),UTST,STS(5),UAST,
    3 UTS(5),UCST,SAS(5),UOST,SCS(5),FP,SOS(5),CMAX,SSTR1(5),
    4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UOS(5),UPRITM,USTR(5),
    5 UPRITT,UPRIS(5)
      DATA  PRTOT, ERSNTT/2*0.0/
      DATA  PRTOM, ERSNTM/2*0.0/
      DATA  RUTOM, RCSTOM, RITOM, RINTOM, NEPTOM/5*0.0/
      DATA  RUTOT, RCSTOT, RITOT, RINTOT, NEPTOT/5*0.0/
      DATA  ROBTOM, ROBTOT, INFTOM, INFTOT, ROITOM, ROITOT/30*0.0/
      DATA  TWBAL, RESB, SRGX, INTF, ERSTOM, ERSTOT/25*0.0/
      DATA  RESB1, BASTOM, RCHTOM, BASTOT, RCHTOT/9*0.0/
      DATA  EPTOM, EPTOT/2*0.0/, PRNTKE/0/
      DATA  PR, P3, RXB, RGX, INFL, UZSB, APERCB, DPST/28*0.0/
      DATA  TIMFAC/0/, UZSN, LZSN, INFIL, INTER, IRC, NN, L, SS/8*0.0/
      DATA  A, UZS, LZS, SGW, GWS, KV, K24L, KK24/8*0.0/
      DATA  IFS, K24EL, K3, EPXM, COVER, COVRMX/17*0.0/
      DATA  ERSN/5*0.0/, SRER/5*0.0/, SRERT/0.0/
      DATA  AREA, M/2*0.0/
      DATA  MUZ, MLZ/2*0.0/
      DATA  MNAM/' JANUARY','FEBRUARY',' MARCH ',' APRIL ',
    *             '  MAY   ','  JUNE  ','  JULY  ',' AUGUST ',
    *             'SEPTMBER',' OCTOBER','NOVEMBER','DECEMBER'/
      DATA  MMPIN/25.4/, METOPT/0.3072/
      DATA  SMOIST/120*0.0/,UMOIST/120*0.0/,LMOIST/24*0.0/
      DATA  STEMP/24*0.0/,UTEMP/24*0.0/,LTEMP/0.0/
      DATA SUMSNM, PXSNM, MELRAM, RADMEM, CONMEM, CRAINM,
     *       CONMEM, SGMM, SNEGMM, SEVAPM, SUMSNY, PXSNY, MELRAY,
     *       RADMEY, CONMEY, CONMEY, CRAINY, SGMY, SNEGMY, SEVAPY,
     *       TSNBAL/21*0.0/,PACK/0.0/,SDEN/0.0/,PETMAX/0.0/
      DATA CALB/'CALB'/,PROD/'PROD'/
      DATA ENGL/'ENGL'/,METR/'METR'/,BOTH/'BOTH'/
      DATA NO/'NO'/,YES/'YES'/
      DATA  JCOUNT/0/
      DATA  HOUR/'HOUR'/,DAYS/'DAYS'/,MNTH/'MNTH'/,INTR/'INTR'/
      DATA ON/'ON'/,OFF/'OFF'/
C
      DATA  LN/20*0.0/,UN/100*0.0/,UNI/100*0.0/
      DATA  SN/100*0.0/,SNT/20*0.0/,UNIT/20*0.0/,KN/32*0.0/
      DATA  THKN/8*0.0/,KP/20*0.0/,THKP/5*0.0/,UNT/20*0.0/
      DATA  DELT,NBAL,PHBAL,CLBAL/4*0.0/
      DATA  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG/6*0/
      DATA  SNRSM/100*0.0/,SNROM/100*0.0/,UNRIM/100*0.0/,NRSM/100*0.0/,
     1      LNRPM/20*0.0/,SNRBM/100*0.0/,UNRBM/100*0.0/,LNRBM/20*0.0/,
     2      GNRBM/20*0.0/,TNRBM/20*0.0/,SNRSY/100*0.0/,SNROY/100*0.0/,
     3      UNRIY/100*0.0/,NRSY/100*0.0/,LNRPY/20*0.0/,SNRBY/100*0.0/,
     4      UNRBY/100*0.0/,LNRBY/20*0.0/,GNRBY/20*0.0/,TNRBY/20*0.0/,
     5      TNRHV/20*0.0/,TNRHVM/20*0.0/,TNRHVY/20*0.0/,
     6      TNA/0.0/,TPA/0.0/,T[illegible]A/0.0/
C
      DATA STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITOM,SOST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTRI,SPROTT,UAS,SPRSTT,UCS,
     4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS/102*0.0/
C
C        INITIALIZE DATA FOR DISK WRITING
C
      DATA DSNFLO,DSNERS,TMBLSZ/2*0,128/,DSNROS/0/
      DATA LSRO,ERCS/256*0./,RROS/128*0.0/
      DATA LOOP/0/,NEROS/1/,NILSRO/1/,NRROS/1/
      END
C
C
C
C
      SUBROUTINE LANDS(SFLAG,SNOPRT)
C
C
C                                 HSP LANDS
C
C
      IMPLICIT  REAL(L,K)
C
      DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),RUZB(5),
     1 UZSB(5),APERCB(5),RIB(5),ERSN(5),K3(12)
      DIMENSION SRER(5),ROBTOM(5),ROBTOT(5),INFTOM(5),INFTOT(5),
     1 ROITOM(5),ROITOT(5),RXB(5),ERSTOM(5),ERSTOT(5),MNAM(12),RAD(24),
     2 TEMPX(24),WINDX(24),RAIN(288),UZSBMT(5),RESBMT(5),SRGXMT(5)
      DIMENSION SHRO(5),RXX(5),DEEPL(5),UZRA(5),PRE(5),INFL(5),UZI(5),
     1 EVDIST(24),ROSINT(5),PERCB(5),
     2 ARCSP(5),AINTF(5),AROSIT(5),LAPSE(24),SVP(40),SNOUT(24,16)
      DIMENSION LSRO(128),ERCS(128),RROS(128)
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1           STEMP(24),UTEMP(24)
C
      COMMON /ALL/ KC,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
     2 CALB,PROD,PEST,NJTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
     3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
     4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
               1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
               2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
               3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
               4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
               5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
               6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
               7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
               8 MELRAM,RADMEM,CONMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
               9 PXSNY,MELRAY,RADMEY,CONMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
               * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
               1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
               2 DSNFLO,DSNERS,LSRO,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
       C
       C   COMMON ALL DECLARATIONS FOR I*2 & R*4
             INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
             REAL  PU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
            1       UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
            2       LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
       C
       C   COMMON LAND DECLARATIONS FOR I*2 & R*4
             INTEGER  DAY,MONTH,DSNROS,DSNFLO,DSNERS,TMBLSZ,NEROS,
            1          NILSRO,NRROS
             REAL  SEVAPM,SUMSNY,PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,
            1       CRAINY,SNEGMY,SEVAPY,TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,
            2       RXB,ROITOM,PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,
            3       IPACK,TMIN,SUMSNM,PXSNM,XK3,MELRAM,RADMEM,CORMEM,CRAINM,
            4       CONMEM,SGMM,SNEGMM,PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,
            5       NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,NEPTOT,
            6       ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
            7       UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,
            8       KV,K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,
            9       SCEP1,SRGXT,SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,
            *       METOPT,CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,
            1       TSNOW,PETMIN,ROITOT,INFTOM,INFTOT,ERSTOM,ERSTOT,SRER,
            2       TEMPX,RAD,WINDX,RAIN,LSRO,EROS,RROS
       C
             INTEGER  HRFLAG,H,SFLAG
             INTEGER  LASTLP,LASTRO
             INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
            1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
             INTEGER*4  LOOP,SNOPRT
        C
              DOUBLE PRECISION  MNAM
        C
             REAL  IRC4, INFLT, QMETRC
             REAL  UZSMET, LZSMET, SGWMET, SCEPMT, RESSMT
             REAL  TWBLMT, SRGXTM, RESBMT, SRGXMT
             REAL KUGI, NEGMLT, NEGMM, PRJ
             REAL MELT, INDT, KCLD, MELRAD
        C
             INTEGER*2 TF1,III
        C
             DATA  IHRR, HRFLAG/2*0/
             DATA  PERC, INFLT/0.0,0.0/
             DATA  SBAS/0.0/
             DATA  SNET1, SNET, SRCH/3*0.0/, NUMI/0/
             DATA  ROSINT/5*0.0/, AETR, RF/2*0.0/
             DATA  PEPIN, EPIN, EPIN1, EPHR/4*0.0/
             DATA  EVDIST/6*0.0,0.019,0.041,0.067,0.088,0.102,3*0.11,0.105,
            C      0.095,0.081,0.055,0.017,5*0.0/
             DATA SVP/10*1.005,1.01,1.01,1.015,1.02,
            *1.03,1.04,1.06,1.08,1.1,1.29,1.66,2.13,2.74,3.49,4.40,5.55,6.87,
            *8.36,10.09,12.19,14.63,17.51,20.86,24.79,29.32,34.61,40.67,47.68,
            *55.71,64.88/
             DATA LAPSE/6*3.5,3.7,4.0,4.1,
            *4.3,4.6,4.7,4.8,4.9,5.0,5.0,4.8,4.6,4.4,4.2,4.0,3.8,3.7,3.6/
             DATA  APR, AEPIN/2*0.0/
             DATA  AROSB, AINTF, AROSIT/15*0.0/
```

```
      DATA  ARO, AROI, AROS, ARGXT, ASNET, ASBAS, ASRCH/7*0.0/
      DATA  SUMSN, INOT, KCLD, PXONSN, SEVAPT, RADME, CORME, LIQW1,
     *      CONME, CRAIN, NEGMLT, SNEGM, NEGMM, LIQS,  LIQW, XICE,
     *      XLNMLT,SGP, SPX, WBAL, SEVAP/21*0.0/
      DATA RA,LW,PX,MELT,CONV,RAINM,CONDS /7*0./
      DATA  SNOUT/384*0.0/,CLDF/-1.0/,ALBEDO/0.85/
      DATA  SUMSND,PXSND,MELRAD,RADMED,CORMED,CONMED,CRAIND,SGMD,
     1      SNEGMD,SEVAPD/10*0.0/
      DATA IEND/0/, LASTRD/0/, PRO/0.0/
C
C                         ZEROING OF VARIABLES
C
      LZS1 = LZS
      UZS1 = UZS
      NUMI = 0
      DPST = 0.0
      PACK1 = PACK
      LIQW1 = LIQW
      PRR = PR
C
      DO 184 I=1,5
  184   APERCB(I) = 0.0
C
       PA=1.0-A
       IRC4=IRC**(1.0/96.0)
       LIRC4=1.0-IRC4
       KK4=KK24**(1.0/96.0)
       LKK4= 1.0 - KK4
C
      IF ((1440./TIMFAC).LE.100.) GO TO 187
      LIRC4 = LIRC4/3.0
      LKK4 = LKK4/3.0
C
  187 DEC= 0.00982*((NN*L/SQRT(SS))**0.6)
      SPC= 1020.*SQRT(SS)/(NN*L)
C
      RESS = 0.0
      LNRAT=LZS/LZSN
      D3FV=(2.0*INFIL)/(LNRAT*LNRAT)
      D4F= (TIMFAC/60.)*D3FV
C                                            REDUCE INFILTRATION IF ICE EXISTS
C                                             AT THE BOTTOM OF THE PACK -
C                                           ATTEMPT TO CORRECT FOR FROZEN LAND
      IF (SNOW .EQ. NO)  GO TO 188
      D4FX = (1.0 -XICE)
      IF (D4FX .LT. 0.1)  D4FX = 0.1
      D4F = D4F*D4FX
      SUMSNH = 0.0
      PXSNH = 0.0
      RADMEH = 0.0
      CORMEH = 0.0
      CONMEH = 0.0
      CRAINH = 0.0
      SGMH = 0.0
      SNEGMH = 0.0
      SEVAPH = 0.0
      SPXH = 0.0
C
  188 RATIO= INTER*EXP(0.693147*LNRAT)
      IF ((RATIO).LT.(1.0)) RATIO=1.0
      D4RA= D4F*RATIO
      H = TF/24
C
C                                          TF IS 1 FOR RAIN DAYS, AND 96
C                                          OR 288 FOR NON-RAIN DAYS
C
      IF (TF .GT. 2)  IHRR=0
C
```

```
      TFI=TF
      DO 155  III=1,TFI
C
      LOOP = LOOP + 1
      LNRAT = LZS/LZSN
      IF (TF .LT. 2)  GO TO 4
      NUMI =NUMI + 1
      IF (NUMI .NE. N)  GO TO 4
      NUMI = 0
C
  4   SBAS = 0.0
      SRCH = 0.0
      ROS = 0.0
      RJ = 0.0
      GWF = 0.0
      RGXT = 0.0
      PERC = 0.0
      INFLT = 0.0
C
C    TIMFAC - TIME INTERVAL IN MINUTES
C    L       - LENGTH OF OVERLAND SLOPE
C    NN      - MANNING'S N FOR OVERLAND SLOPE
C    A       - IMPERVIOUS AREA
C    PA     - PERVIOUS AREA
C
C
C
C
C PR IS INCOMING RAINFALL
C P3 IS RAIN REACHING SURFACE(.00'S INCHES)
C P4 IS TOTAL MOISTURE AVAILABLE( IN.)
C RESS  IS OVERLAND FLOW STORAGE( IN.)
C D4F IS 'B' IN OP. MANUAL
C RATIO IS 'C' IN OP. MANUAL
C EP --  DAILY EVAP ( IN.)
C EPHR - HOURLY EVAP
C EPIN - INTERVAL EVAP
C EPXX - FACTOR FOR REDUCING EVAP FOR SNOW AND TEMP
C
C
C
C
C       DETERMINE IF SNOWMELT IS TO BE DONE
C
      HRFLAG=0
      ITEST = IMIN/TIMFAC
      IF (NUMI .EQ. 1)  HRFLAG = 1
      IF (ITEST.EQ.1)  HRFLAG = 1
C
C       HRFLAG=1 INDICATES BEGINNING OF THE HOUR
C
      IF (HRFLAG.EQ.0) GO TO 999
      IEND = 0
      IF (IHR.EQ.24) GO TO 202
      IHRR = IHR + 1
      GO TO 501
  202 IHRR = IHRR + 1
  501 EPHR = EVDIST(IHRR)*EP
      IF (EPHR.LE.(0.0001))  EPHR=0.0
      EPIN = EPHR
      EPIN1 = EPIN
      IF (SNOW .EQ. NO) GO TO 999
      IF ((PACK .LE. 0.0).AND.(TMIN .GT. PETMAX))  GO TO 999
C                                 ************************************
C                                                BEGIN SNOWMELT
C                                 ************************************
      TSNOW1 = TSNOW + 1.
      SEVAP = 0.0
      SFLAG = 0
      PRHR = 0.0
      IKEND = 60./(TIMFAC)
      IPT = (IHRR-1)*IKEND
C                               SUM PRECIP FOR THE HOUR
      PX = 0.0
      DO 502 II = 1,IKEND
  502 PRHR = PRHR + RAIN(IPT+II)
C                                   CORRECT TEMP FOR ELEVATION DIFF
C                                   USING LAPSE RATE OF 3.5 DURING RAIN
C                                   PERIODS, AND AN HOURLY VARIATION IN
C                                   LAPSE RATE (LAPSE(I)) FOR DRY PERIOD
C
      LAPS = LAPSE(IHRR)
      IF (PRHR .GT. 0.05)  LAPS = 3.5
      TX = TEMPX(IHRR) - LAPS*ELDIF
C
C
C                                 REDUCE REG EVAP FOR SNOWMELT
C                                 CONDITIONS BASED ON PETMIN AND
C                                 PETMAX VALUES
C
      IF (PACK.LE.IPACK) GO TO 504
      E1E = 0.0
      PACKRA = 1.0
      GO TO 505
  504 PACKRA = PACK/IPACK
      E1E = 1.0 - PACKRA
  505 EPXX = (1.0-F)*E1E + F
      IF (TX.GE.PETMAX) GO TO 512
      IF (EPXX .GT. 0.5)  EPXX = 0.5
C
C                                REDUCE EVAP BY 50% IF TX IS BETWEEN
C                                PETMIN AND PETMAX
      IF (TX.LT.PETMIN) EPXX = 0.0
C
C
  512 EPHR = EPHR*EPXX
      EPIN = EPIN*EPXX
      IEND = 0
      SNBAL = 0.0
      IF ((TX .GT. TSNOW) .AND. (PRHR .GT. .02)) DEWX = TX
C
C     SET DEWPT TEMP EQUAL TO AIR TEMP WHEN RAINING
C     ON SNOW TO INCREASE SNOWMELT
C
      IF (DEWX .GT. TX) DEWX = TX
      SNTEMP = TSNOW + (TX-DEWX)*(0.12 + 0.008*TX)
C
C     RAIN/SNOW TEMP. DIVISION - SEE ANDERSON, WRR, VOL. 4, NO. 1,
C     FEB. 1968, P. 27, EQ. 28
C
      IF (SNTEMP .GT. TSNOW1) SNTEMP = TSNOW1
      IF (TX.LT.SNTEMP) GO TO 521
      IF  (PACK) 997, 997, 525
  521 SFLAG = 1
      IF ((PACK.LE.0.0) .AND. (PRHR.LE.0.0))  GO TO 997
C
C     SKIP SNOWMELT IF BOTH PACK AND PRECIP ARE ZERO
C     FOR THE HOUR
C
  525 IEND = 1
C
C     SNOWMELT CALCULATIONS ARE DONE IF IT IS SNOWING, OR,
C     IF A SNOWPACK EXISTS
C
      PX = PRHR
      IF (PX.LE.0.0) GO TO 550
C                                 KCLD IS INDEX TO CLOUD COVER
      KCLD = 35.
      IF (SFLAG.LE.0) GO TO 555
C                                SNOW IS FALLING
      PX = PX*SCF
      APR = APR + (SCF-1.0)*PRHR
      PRHR = PRHR*SCF
      SUMSN = SUMSN + PX
      DNS = IDNS
      IF (TX .GT. 0.0)  DNS = DNS + ((TX/100.)**2)
C
C     SNOW DENSITY WITH TEMP. - APPROX TO FIG. 4, PLATE B-1
C     SNOW HYDROLOGY  SEE ALSO ANDERSON, TR 36, P. 21
C
      PACK = PACK + PX
C
      IF (PACK.LE.IPACK) GO TO 548
      IPACK = PACK
      IF (IPACK .GT. MPACK)  IPACK = MPACK
C
  548 DEPTH = DEPTH + (PX/DNS)
      IF (DEPTH .GT. 0.0) SDEN = PACK/DEPTH
      INDT = INDT - 1000*PX
      IF (INDT .LT. 0.0) INDT = 0.0
      PX = 0.0
      GO TO 555
  550 KCLD = KCLD - 1.
  555 IF (KCLD .LT. 0.0) KCLD = 0.0
      PACKRA = PACK/IPACK
      IF (PACK .GT. IPACK)  PACKRA = 1.0
C
      IF (PACK.GE.0.005) GO TO 580
C
C     IPACK IS AN INDEX TO AREAL COVERAGE OF THE SNOWPACK
C     FOR INITIAL STORMS IPACK = .1*MPACK SO THAT COMPLETE
C     AREAL COVERAGE RESULTS.  IF EXISTING PACK > .1 *MPACK THEN
C     IPACK IS SET EQUAL TO MPACK WHICH IS THE WATER EQUI. FOR
C     COMPLETE AREAL COVERAGE PACKRA IS THE FRACTION AREAL COVERAGE
C     AT ANY TIME.
C
      IPACK = 0.1*MPACK
      XICE = 0.0
      XLNMLT = 0.0
      NEGMLT = 0.0
      PX = PX + PACK + LIQW
      PACK = 0.0
      LIQW = 0.0
C
C     ZERO SNOWMELT OUTPUT ARRAY
C
      DO 570 I=1,24
        DO 570 MM=1,16
  570     SNOUT(I,MM) = 0.0
      GO TO 997
C
C
  580 PXONSN = PXONSN + PX
      IF (DEPTH .GT. 0.0) SDEN = PACK/DEPTH
      IF (INDT .LT. 800.) INDT = INDT + 1.
C                                INDT IS INDEX TO ALBEDO
      MELT = 0.0
      IF (SDEN .LT. 0.55) DEPTH=DEPTH*(1.0 - 0.00002*(DEPTH*(.55-SDEN)))
C
C     EMPIRICAL RELATIONSHIP FOR SNOW COMPACTION
C
      IF (DEPTH .GT. 0.0) SDEN = PACK/DEPTH
      WIN = WINDX(IHRR)
```

```
C
C     HOURLY WIND VALUE
C
      LREF = (TX + 100.)/5
      LREF = IFIX(LREF)
      SVPP = SVP (LREF)
      ITX = IFIX(TX)
      SATVAP = SVPP +(MOD(ITX,5)/5)*(SVP(LREF + 1) - SVPP)
      LREF = (DEWX + 100.)/5
      LREF = IFIX(LREF)
      SVPP = SVP (LREF)
      IDEWX = IFIX(DEWX)
      VAPP = SVPP + (MOD(IDEWX,5)/5)*(SVP(LREF + 1) - SVPP)
C                   CALCULATION OF VAPOR PRESSURE AT AIRTEMP
C                   AND DEWPOINT
      SEVAP = 0.0
      IF (VAPP.LE.6.108) GO TO 610
      CNM = 8.59*(VAPP - 6.108)
      GO TO 620
  610 CNM = 0.0
      DUMMY=(VAPP-SATVAP)*PACKRA
      IF (VAPP .LT. SATVAP) SEVAP = EVAPSN*0.0002*WIN*DUMMY
      PACK = PACK + SEVAP
      SEVAPT = SEVAPT - SEVAP
C
C     CONDENSATION - CONVECTION MELT, EQ. T-29B, P.176, SNOW HYDROLOGY
C     CONV - CONVECTION, CONDS - CONDENSATION
C     SEVAP - EVAP FROM SNOW (NEGATIVE VALUE)
C
  620 CNV = 0.0
      IF (TX .GT. 32.) CNV = (TX-32.)*(1.0 - 0.3*(MELEV/10000.))
      CCXC = CCFAC*.00026*WIN
C
C     .00026 = .00629/24, I.E. .00026 IS THE DAILY COEFFICIENT
C     (FROM SNOW HYDROLOGY) REDUCED TO HOURLY VALUES.
C
      CONV = CNV*CCXC
      CONDS = CNM*CCXC
C                       CLOUD COVER
C                       CLDF IS FRACTION OPEN SKY - MINIMUM VALUE 0.15
      IF (IHRR.EQ.1 .OR. CLDF.LT.0.0) CLDF = (1.0 - 0.085*(KCLD/3.5))
C                       ALBEDO
      IF (MONTH.GT.9) GO TO 640
      IF (MONTH.LT.4) GO TO 640
      ALBEDO = 0.8 - 0.1*(SQRT(INDT/24.))
      IF (ALBEDO .LT. 0.45)  ALBEDO = 0.45
      GO TO 650
  640 ALBEDO = 0.65 - 0.07*(SQRT(INDT/24.0))
      IF (ALBEDO .LT. 0.6)  ALBEDO = 0.6
C                       SHORT WAVE RADIATION-RA - POSITIVE INCOMING
  650 RA = RAD(IHRR)*(1.0 -ALBEDO)*(1.0-F)
C                       LONG WAVE RADIATION - LW - POSITIVE INCOMING
      DEGHR = TX - 32.0
      IF (DEGHR.LE.0.0) GO TO 660
      LW = F* 0.26*DEGHR + (1.0 - F)*(0.2*DEGHR - 6.6)
      GO TO 665
  660 LW = F*0.2*DEGHR + (1.0 - F)*(0.17*DEGHR - 6.6)
C
C                           LW IS A LINEAR APPROX. TO CURVES IN
C                           FIG. 6, PL 5-3, IN SNOW HYDROLOGY.  6.6
C                           IS AVE BACK RADIATION LOST FROM THE SNOWPACK
C                           IN OPEN AREAS, IN LANGLEYS/HR.
C
C                           CLOUD COVER CORRECTION
  665 IF (LW .LT. 0.0)  LW = LW*CLDF
C
C                           RAIN MELT
      RAINM = 0.0
```

```
C
C                                         RAINMELT IS OPERATIVE IF IT IS
C                                         RAINING AND TEMP IS ABOVE 32 F
C
      IF ((SFLAG .LT. 1).AND.(TX .GT. 32.))  RAINM = DEGHR*PX/144.
C                              TOTAL MELT
      RM = (LW + RA)/203.2
C                              203.2 LANGLEYS REQUIRED TO PRODUCE I INCH
C                              RUNOFF FROM SNOW AT 32 DEGREES F
      IF (PACK.GE.IPACK) GO TO 680
      RM = RM*PACKRA
      CONV = CONV*PACKRA
      CONDS = CONDS*PACKRA
      RAINM = RAINM*PACKRA
      IF (IHRR.NE.6) GO TO 680
      XLNEM = 0.01*(32.0 - TX)
      IF (XLNEM .GT. XLNMLT) XLNMLT = XLNEM
  680 RADME = RADME + RM
      CORME = CORME + CONDS
      CONME = CONME + CONV
      CRAIN = CRAIN + RAINM
      MELT = RM + CONV + CONDS + RAINM
C
      TP = 32.0 - (NEGMLT/(0.00695*PACK))
C
C     TP IS TEMP OF THE SNOWPACK
C     0.00695 IS IN. MELT/IN. SNOW/DEGREE F
C
      IF (MELT.GE.0.0) GO TO 700
      NEGMM = 0.0
      IF (TX .LT. 32.) NEGMM = 0.00695*(PACK/2.0)*(32.0 - TX)
C
C                                         HALF OF PACK IS USED TO CALCULATE
C                                         MAXIMUM NEGATIVE MELT
C
      IF (TP.LE.TX) GO TO 695
      GM = 0.0007*(TP - TX)
      NEGMLT = NEGMLT + GM
      SNEGM = SNEGM + GM
  695 IF (NEGMLT .GT. NEGMM)  NEGMLT = NEGMM
      MELT = 0.0
C
C                                  MELTING PROCESS BALANCE
C
  700 PXBY = (1.0 - PACKRA)*PX
      PX = PACKRA*PX
C
C     PXBY IS FRACTION OF PRECIP FALLING ON BARE GROUND
C
      IF ((MELT + PX).LE.0.0) GO TO 795
C
C     SATISFY NEGMLT FROM PRECIP(RAIN) AND SNOWMELT
C
      IF (MELT.GE.NEGMLT) GO TO 720
      NEGMLT = NEGMLT - MELT
      MELT = 0.0
      GO TO 725
  720 MELT = MELT - NEGMLT
      NEGMLT = 0.0
C
  725 IF (PX.GE.NEGMLT) GO TO 735
      NEGMLT = NEGMLT - PX
      PACK = PACK + PX
      PX = 0.0
      GO TO 740
  735 PX = PX - NEGMLT
      PACK = PACK + NEGMLT
      NEGMLT = 0.0
```

```
C
  740 IF ((PX + MELT) .EQ. 0.0) GO TO  800
C
C     COMPARE SNOWMELT TO EXISTING SNOWPACK AND WATER CONTENT OF
C     THE PACK
C
      IF (MELT.LE.PACK) GO TO 750
      MELT = PACK + LIQW
      DEPTH = 0.0
      PACK = 0.0
      LIQW = 0.0
      INDT = 0.0
      GO TO 765
  750 PACK = PACK - MELT
      IF (SDEN .GT. 0.0)  DEPTH = DEPTH - (MELT/SDEN)
      IF (PACK .GE. (0.9*DEPTH))  DEPTH = 1.11*PACK
      IF (PACK.GE.0.001) GO TO 760
      LIQW = LIQW + PACK
      PACK = 0.0
  760 LIQS = WC*PACK
      IF (SDEN .GT. 0.6) LIQS = WC*(3.0 - (3.33)*SDEN)*PACK
      IF (LIQS .LT. 0.0) LIQS = 0.0
C
C     COMPARE AVAILABLE MOISTURE WITH AVAILABLE STORAGE IN SNOWPACK
C     -LIQS
C
  765 IF ((LIQW + MELT + PX).LE.LIQS) GO TO 775
      PX = MELT + PX + LIQW - LIQS
      LIQW = LIQS
      GO TO 780
  775 LIQW = LIQW + MELT + PX
      PX = 0.0
  780 IF (PX.LE.XLNMLT) GO TO 790
      PX = PX - XLNMLT
      PACK = PACK + XLNMLT
      XICE = XICE + XLNMLT
      XLNMLT = 0.0
      GO TO 795
  790 PACK = PACK + PX
      XICE = XICE + PX
      XLNMLT = XLNMLT - PX
      PX = 0.0
  795 IF (XICE .GT. PACK) XICE = PACK
C
C
C                                     END MELTING PROCESS BALANCE
C
  800 IF (DEPTH .GT. 0.0) SDEN = PACK/DEPTH
      IF (SDEN .LT. 0.1) SDEN = 0.1
C                                          GROUNDMELT
      IF (IHRR.NE.12) GO TO 830
      DGMM = DGM
      IF (TP .LT. 5.0)  TP = 5.0
      IF (TP .LT. 32.)  DGMM = DGMM - DGM*.03*(32.0 - TP)
      IF (PACK.LE.DGMM) GO TO 825
      PX = PX + DGMM
      PACK = PACK - DGMM
      DEPTH = DEPTH - (DGMM/SDEN)
      SGM = SGM + DGMM
      GO TO 830
  825 PX = PACK + PX + LIQW
      SGM = SGM + PACK
      PACK = 0.0
      DEPTH = 0.0
      LIQW = 0.0
      NEGMLT = 0.0
  830 CONTINUE
      PX = PX + PXBY
      SPX = SPX + PX
C
C                                     HOUR VALUE ASSIGNMENT
  997 SUMSNH = SUMSN
      PXSNH = PXONSN
      SPXH = SPX
      RADMEH = RADME
      CORMEH = CORME
      CONMEH = CONME
      CRAINH = CRAIN
      SGMH = SGM
      SNEGMH = SNEGM
      SEVAPH = SEVAPT
C
C                                     DAILY SUMS
      IF (PRINT.NE.DAYS)  GO TO 996
      SUMSND = SUMSND + SUMSN
      PXSND  = PXSND  + PXONSN
      MELRAD = MELRAD + SPX
      RADMED = RADMED + RADME
      CORMED = CORMED + CORME
      CONMED = CONMED + CONME
      CRAIND = CRAIND + CRAIN
      SGMD   = SGMD   + SGM
      SNEGMD = SNEGMD + SNEGM
      SEVAPD = SEVAPD + SEVAPT
C
C                                     MONTHLY SUMS
  996 SUMSNM = SUMSNM + SUMSN
      PXSNM  = PXSNM  + PXONSN
      MELRAM = MELRAM + SPX
      RADMEM = RADMEM + RADME
      CORMEM = CORMEM + CORME
      CONMEM = CONMEM + CONME
      CRAINM = CRAINM + CRAIN
      SGMM   = SGMM   + SGM
      SNEGMM = SNEGMM + SNEGM
      SEVAPM = SEVAPM + SEVAPT
C
C                                     YEARLY SUMS
      SUMSNY = SUMSNY + SUMSN
      PXSNY  = PXSNY  + PXONSN
      MELRAY = MELRAY + SPX
      RADMEY = RADMEY + RADME
      CORMEY = CORMEY + CORME
      CONMEY = CONMEY + CONME
      CRAINY = CRAINY + CRAIN
      SGMY   = SGMY   + SGM
      SNEGMY = SNEGMY + SNEGM
      SEVAPY = SEVAPY + SEVAPT
C
C                                     ZERO HOURLY VALUES
      SUMSN = 0.0
      PXONSN = 0.0
      SPX = 0.0
      RADME = 0.0
      CORME = 0.0
      CONME = 0.0
      CRAIN = 0.0
      SGM = 0.0
      SNEGM = 0.0
      SEVAPT = 0.0
C
C                               SNOWMELT OUTPUT
C
C
C
      SNOUT(IHRR,1) = PACK
```

```
          SNOUT(IHRR,2) = DEPTH
          SNOUT(IHRR,3) = SDEN
          SNOUT(IHRR,4) = ALBEDO
          SNOUT(IHRR,5) = CLDF
          SNOUT(IHRR,6) = NEGMLT
          SNOUT(IHRR,7) = LIQW
          SNOUT(IHRR,8) = TX
          SNOUT(IHRR,9) = RA
          SNOUT(IHRR,10) = LW
          SNOUT(IHRR,11) = PX
          SNOUT(IHRR,12) = MELT
          SNOUT(IHRR,13) = CONV
          SNOUT(IHRR,14) = RAINM
          SNOUT(IHRR,15) = CONDS
          SNOUT(IHRR,16) = XICE
C
          IF (OUTPUT .EQ. ENGL)  GO TO 845
          IF (OUTPUT .EQ. BOTH .AND. INPUT .EQ. ENGL)  GO TO 845
C
C  CONVERSION TO METRIC SNOW OUTPUT
C
            SNOUT(IHRR,1) = PACK*MMPIN
            SNOUT(IHRR,2) = DEPTH*MMPIN
            SNOUT(IHRR,6) = NEGMLT*MMPIN
            SNOUT(IHRR,7) = LIQW*MMPIN
            SNOUT(IHRR,8) = 0.556*(TX-32.0)
            DO 842 ISNOUT=11,16
               SNOUT(IHRR,ISNOUT) = SNOUT(IHRR,ISNOUT)*MMPIN
  842       CONTINUE
C
  845 IF (HYCAL.EQ.PROD)  GO TO 998
          IF (SNOPRT .EQ. NO)  GO TO 998
C
          IF (IHRR .NE. 24)  GO TO 998
          IF (PACK.LE.0.0)  GO TO 998
          WRITE (6,992) MNAM(MONTH),DAY
          WRITE(6,990)
C
          DO 880 I=1,24
             WRITE (6,991) I,(SNOUT(I,MM),MM=1,16)
            DO 881 MMM=1,16
               SNOUT(I,MMM) = 0.0
  881       CONTINUE
  880 CONTINUE
          IF (NUTR.EQ.YES)  GO TO 998
          WRITE (6,994)
          WRITE (6,995)
C
C
  990 FORMAT ('0','HOUR     PACK      DEPTH    SDEN  ALBEDO  CLDF   NEGMELT
     1    LIQW      TX      RA   LW     PX       MELT      CONV       RAINM
     2CONDS      ICE')
  991 FORMAT (' ',I2,2X,2(F8.2,2X),3(F6.3,1X),2(F8.3,1X),
     1         F7.2,1X,2(F4.0,1X),5(F8.3,1X),F6.1)
  992 FORMAT ('0',25X,'SNOWMELT OUTPUT FOR',4X,A8,2X,I2)
  994 FORMAT ('0',5X,'DATE',4X,'TIME',4X,'FLOW(CFS-CMS)',6X,
     X         'SEDIMENT (LBS-KG-KG/MIN-GM/L)',23X,
     X         'PESTICIDE (GM-GM/MIN-PPM)')
  995 FORMAT (' ',87X,'WATER',24X,'SEDIMENT')
C
C                                CORRECT WATER BALANCE FOR SNOWMELT
C                                PACK AND SNOW EVAP
C
C                                PRR IS INCOMING PRECIP
C                                PX  IS MOISTURE TO THE LAND SURFACE
C                                SEVAP IS SNOW EVAP - NEGATIVE
  998 IF (IEND.EQ.1)  SNBAL = PRHR+SEVAP-PX-PACK+PACK1-LIQW+LIQW1
          IF ((SNBAL.LT.0.0001).AND.(SNBAL.GT.-0.0001))  SNBAL=0.0
```

```
      TSNBAL = TSNBAL + SNBAL
C
C
      PACK1 = PACK
      LIQW1 = LIQW
C                 ************************************
C                             END SNOWMELT
C                 ***********************************
C                                             PX IS TOTAL MOISTURE INPUT TO
C                                             THE LAND SURFACE FROM PRECIP
C                                             AND SNOWMELT DURING THE HOUR
C
  999 IF (IEND .GT. 0) PR=PX*TIMFAC/60.
C                                          IEND>0 INDICATES SNOWMELT
C                                          OCCURRED DURING THE HOUR
C
C
C
C
C   * * *    INTERCEPTION  FUNC.     * * *
C
C
C EPXM - MAX. INTERCEPTION STORAGE
C SCEP - EXISTING INTER. STORAGE
C EPX  - AVAILABLE INTER. STORAGE
C RUI  - IMPERVIOUS RUNOFF DURING INTERVAL
C
C
C
        IF (COVER.GT.0.0001) GO TO 204
        SNET = SNET + SCEP
        SCEP = 0.0
        EPX = 0.0
        GO TO 203
C
C
 204    EPX = EPXM*(COVER/COVRMX)-SCEP
        IF (EPX.LT.(0.0001))  EPX = 0.0
        IF (PR.LT.EPX) GO TO 205
  203   P3 = PR-EPX
        RU = P3*A
        RUI = RU
        SCEP = SCEP+EPX
        GO TO 206
  205   SCEP = SCEP+PR
        P3 = 0.0
        RU = 0.0
        RUI = 0.0
C
C
C
C   * * *      INTERCEPTION EVAP      * * *
C
C
  206  IF ((NUMI.NE.0).OR.(IMIN.NE.0)) GO TO 221
       IF (SCEP.LE.0.0) GO TO 221
       IF (SCEP.GE.EPIN) GO TO 210
       EPIN = EPIN - SCEP
       SNET = SNET + SCEP
       SCEP = 0.0
       GO TO 221
  210  SCEP = SCEP-EPIN
       SNET = SNET+EPIN
       EPIN = 0.0
C
C
C     ***  INFILTRATION FUNC.  ***
C  P4 IS TOTAL MOISTURE IN STORAGE BLOCK
```

```
C  SHRD(I) = SURFACE DETENTION AND INTERFLOW FROM BLOCK I
C  RXX(I)  = SURFACE DETENTION FROM BLOCK I
C  RGXX(I) = INTERFLOW  COMPONENT FROM BLOCK I
C  RGX(I)  = VOLUME TO INTER. DETEN STOR. FROM BLOCK I
C
C
C       BEGINNING OF BLOCK LOOP
C
C
  221 DO 100 I=1,5
      P4 = P3 + RESE(I)
      RESB1(I) = RESB(I)
      IF ((10.*P4).LE.(((2*I)-1)*D4F)) GO TO 10
      SHRD(I) = (P4-(((2*I)-1)*D4F/10.))
      IF ((10.*P4).LE.(((2*I)-1)*D4RA)) GO TO 25
      RXX(I) = (P4-(((2*I)-1)*D4RA/10.))
      GO TO 31
   10 SHRD(I) = 0.0
   25 RXX(I) = 0.0
   31 RGXX  = SHRD(I)-RXX(I)
C
C
C    ***  UPPER ZONE FUNCTION ***
C
C PRE(I)  - % SURFACE DETENTION TO OVERLAND FLOW
C UZSB(I) -  UPPER ZONE STORAGE IN EACH BLOCK
C UZS     - TOTAL UPPER ZONE STORAGE
C RUZB(I) - ADDITION TO U.Z. STORAGE DURING INTERVAL
C
      IF (UZSB(I).LT.0.0)  UZSB(I)=0.0
      UZPA(I) = UZSB(I)/UZSN
      IF (UZRA(I).GT.6.0) GO TO 7
      IF (UZRA(I).GT.2.0) GO TO 8
      UZI(I) = 2.0*ABS((UZRA(I)/2.0)-1.0) +1.0
      PRE(I) = (UZRA(I)/2.0)*((1.0/(1.0+UZI(I)))**UZI(I))
      GO TO 9
    7 PRE(I) = 1.0
      GO TO 9
    8 UZI(I) = (2.0*ABS(UZRA(I)-2.0))+1.0
      PRE(I) = 1.0-((1.0/(1.0+UZI(I)))**UZI(I))
    9 RXB(I) = RXX(I)* PRE(I)
      RGX(I) = RGXX*PRE(I)
      RGXX = 0.0
      RUZB(I) = SHRD(I)-RGX(I)-RXB(I)
      UZSB(I) = UZSB(I)+RUZB(I)
C
        RIB(I) = P4 - RXB(I)
C
C
C
C    * * *      UPPER ZONE EVAP    * * *
C
C
C REPIN - ACCUM DAILY EVAP POT. FOR L.Z. AND GROWATER, I.E
C           PORTION NOT SATISFIED FROM U.Z.
C
C
          IF ((NUMI.NE.0).OR.(IMIN.NE.0)) GO TO 290
          IF (EPIN.LE.(0.0))  GO TO 290
            IF(UZRA(I).LE.2.0) GO TO 230
            IF (UZSB(I).LE.EPIN) GO TO 270
            UZSB(I) = UZSB(I)-EPIN
            RUZB(I) = RUZB(I)-EPIN
            SNET = SNET+PA*EPIN*0.20
            GO TO 290
  230       EFFECT = 0.5*UZRA(I)
            IF (EFFECT.LT.(0.02))  EFFECT = 0.02
            IF (UZSB(I).LE.EPIN*EFFECT)  GO TO 270
          UZSB(I) = UZSB(I)-(EPIN*EFFECT)
          RUZB(I) = RUZB(I)-(EPIN*EFFECT)
          EDIFF = (1.0-EFFECT)*EPIN
          REPIN = REFIN + EDIFF*0.20
          SNET = SNET + (PA*EPIN*EFFECT)*0.20
          GO TO 290
  270     EDIFF = EPIN - UZSB(I)
          REPIN = REFIN + EDIFF*0.20
          SNET = SNET + PA*UZSB(I)*0.20
          UZSB(I) = C.0
          RUZB(I) = C.0
C
C
C    * * * *    INTERFLOW FUNCTION * * *
C
C      SRGX(I) - INTERFLOW DETENTION STORAGE FROM BLOCK I
C      INTF(I) - INTERFLOW LEAVING STORAGE FROM BLOCK I
C      SRGXT - TOTAL INTERFLOW STORAGE
C      RGXT  - TOTAL INTERFLOW LEAVING STORAGE DURING INTERVAL
C
  290   INTF(I) = LIRC4*SRGX(I)
        SRGX(I) = SRGX(I)+(RGX(I)*PA)-INTF(I)
        RU = RU + INTF(I)*0.20
        SRGXT = SRGXT + (RGX(I)*PA-INTF(I))*0.20
        RGXT = RGXT + INTF(I)*0.20
C
C ***    OVERLAND FLOW ROUTING ***
C
C
C  RXB(I)  = VOLUME TO OVERLAND SURFACE DETENTION FROM BLOCK I
C  ROSB(I) = VOLUME OF OVERLAND FLOW TO STREAM FROM BLOCK I
C  RESB(I) = VOLUME OF OVERLAND Q REMAINING ON SURFACE
C                FROM BLOCK I
C
       F1 = RXB(I)-(RESB(I))
       F3 = (RESB(I))+ RXB(I)
       IF (RXB(I).LE.(RESB(I))) GO TO 34
       DE = DEC*((F1)**0.6)
       GO TO 35
    34 DE = (F3)/2.0
    35 IF (F3.GT.(2.0*DE)) DE = F3/2.0
       IF (F3.LE.0.005) GO TO 40
       DUMV = (1.0+0.6*(F3/(2.0*DE))**3.)**1.67
       ROSB(I) = (TIMFAC/60.)*SRC*((F3/2.)**1.67)*DUMV
       IF (ROSB(I) .GT. 0.95*RXB(I))  ROSB(I) = .95*RXB(I)
       GO TO 43
    40 ROSB(I) = 0.0
    43 RESB(I) = RXB(I)-ROSB(I)
       ROSB(I) = ROSB(I)*PA
       ROSINT(I) = ROSB(I) + INTF(I)
C
C
C
C          * * *  UPPER ZONE DEPLETION * * *
C
C  DEEPL(I) - DIFFERENCE IN UPPER AND LOWER ZONE RATIOS
C  PERCB(I) - UPPER ZONE DEPLETION FROM EACH BLOCK
C  PERC     - TOTAL U.Z. DEPLETION
C  INFLT    - TOTAL INFILTRATION
C  ROS      - TOTAL OVERLAND FLOW TO THE STREAM FROM ALL BLOCKS
C
         IF ((NUMI .EQ. 0).AND.(IMIN .EQ. 0))  GO TO 44
         PERCB(I) = C.0
         GO TO 47
C
  44     DEEPL(I)= ((UZSB(I)/UZSN)-(LZS/LZSN))
         IF (DEEPL(I).LE.0.01) GO TO 47
         PERCB(I)=C.1*INFIL*UZSN*(DEEPL(I)**3)
```

```
C
      IF (SNOW .EQ. YES) PERCB(I) = PERCB(I)*D4FX
C
          IF (UZSB(I).GT.PERCB(I)) GO TO 48
          PERCB(I) = UZSB(I)*PERCB(I)/(PERCB(I)+UZSB(I))
          GO TO 47
C
   48     UZSB(I)=UZSB(I)-PERCB(I)
          PERC=PERC+PERCB(I)*0.2
          RUZB(I) = RUZB(I) - PERCB(I)
  47      INFL(I)= P4-SHRD(I)
          INFLT=INFLT + INFL(I)*0.20
      RESS = RESS + RESB(I)*0.2
      UZS = UZS + RUZB(I)*0.20
      ROS = ROS + ROSB(I)*0.2
  100 CONTINUE
      IF (UZS .LE. 0.0001) UZS=0.0
C
C END OF BLOCK LOOP
C
        RU=RU + ROS
        IF ((RESS).GE.(0.0001))  GO TO 302
        LZS = LZS + RESS
        RESS = 0.0
        DO 306  IK= 1,5
  306   RESB(IK)= 0.0
  302   IF (SRGXT.GE.(0.0001))  GO TO 305
        LZS = LZS + SRGXT/PA
        SRGXT = 0.0
          DO 304  IK= 1,5
  304     SRGX(IK)= 0.0
C
C
C    * * * LOWER ZONE AND GROUNDWATER  * * *
C
C  SBAS  - BASE STREAMFLOW
C  SRCH  - SUM OF GRDWATER RECHARGE
C  PREL  - % OF INFILTRATION AND U.Z. DEPLETION ENTERING L.Z
C  F1A   - GROUNDWATER RECHARGE - IE. PORTION OF INFIL.
C           AND U.Z. DEPLETION ENTERING GRDWATER
C  K24L  - FRACTION OF F1A LOST TO DEEP GRDWATER
C
  305      LZI=1.5*ABS((LZS/LZSN)-1.0)+1.0
           PREL=(1.0/(1.0+LZI))**LZI
           IF (LZS.LT.LZSN)  PREL=1.0-PREL*LNRAT
           F3= PREL*(INFLT)
           F1A = (1.0-PREL)*INFLT
           IF ((NUMI.NE.0).OR.(IMIN.NE.0)) GO TO 309
           F3 = F3 + PREL*PERC
           F1A = F1A + (1.0-PREL)*PERC
  309      LZS= LZS+F3
        F1= F1A*(1.0 - K24L)*PA
        GWF=SGW*LKK4*(1.0 + KV*GWS)
        RU = RU + GWF
        SBAS= GWF
        SRCH= F1A*K24L*PA
        SGW = SGW - GWF + F1
        GWS = GWS + F1
C
C   * * *        GROUNDWATER EVAP   * * *
C
C
C LOS  - EVAP LOST FROM GROUNDWATER
C
C     NOTE: EVAP FROM GRDWATER AND LZ IS CALCULATED ONLY DAILY
C
        IF ((HRFLAG.EQ.0).OR.(IHRR.NE.21)) GO TO 101
        IF (GWS .GT. 0.0001)  GWS = 0.97*GWS
      LOS= SGW*K24EL*REPIN*PA
      SGW=SGW - LOS
      GWS=GWS - LOS
      SNET= SNET + LOS
      REPIN= REPIN - LOS
      IF (GWS.LT.(0.0))  GWS=0.0
C
C  * * *        LOWER ZONE EVAP  * * *
C
C AETR - EVAP LOST FROM L.Z.
C
C
      IF (REPIN.LT.(0.0001))  GO TO 351
      LNRAT = LZS/LZSN
      IF (XK3.LT.0.995) GO TO 300
      KF=50.0
      GO TO 320
  300 KF=0.25/(1.0-XK3)
  320 IF (REPIN.GE.(KF*LNRAT))  GO TO 340
      AETR= REPIN*(1.0-(REPIN/(2.0*KF*LNRAT)))
      GO TO 350
  340 AETR= 0.5*(KF*LNRAT)
  350 IF (XK3.LT.(0.50))  AETR=AETR*(2.0*XK3)
      LZS=LZS - AETR
      SNET= SNET + PA*AETR
      ASNET = ASNET + LOS + PA*AETR
  351 REPIN = 0.0
  101 SNETI = SNET - SNET1
C
C        STORE LSRO AND WRITE TO DISK
C
      IF (DSNFLO.EQ.0) GO TO 4010
      LSRO(NILSRO) = RO
      IF (NILSRO.LT.TMBLSZ) GO TO 4000
      IF (OUTPUT.EQ.ENGL) GO TO 4040
      DO 4030 I = 1,TMBLSZ
 4030    LSRO(I) = LSRO(I)*MMPIN
 4040 IF(IDEBUG .EQ. ON) WRITE(6,9996) LOOP
 9996 FORMAT('0','DEBUG - - LOOP = ',I5)
      WRITE(DSNFLO)  (LSRO(I),I=1,TMBLSZ)
      IF(IDEBUG .EQ. ON) WRITE(6,9995) (LSRO(I),I=1,TMBLSZ)
 9995 FORMAT('0','WRITE TO DISK - LSRO ',/,(1X,10(E10.3,2X),/))
      DO 4050 I = 1,TMBLSZ
 4050    LSRO(I) = 0.
      NILSRO = 0
 4000 NILSRO = NILSRO + 1
C
C
 4010 IF (DSNROS .EQ. 0)  GO TO 4011
      IF (ROS .EQ. 0.0)  GO TO 4011
      IF (LOOP .EQ. (LASTRD+1))  GO TO 924
      IHEAD = -LOOP
      RROS(NRROS) = IHEAD
      IF (NRROS .LT. TMBLSZ)  GO TO 922
      IF (OUTPUT .EQ. ENGL)  GO TO 912
      DO 910 I=1,TMBLSZ
  910    RROS(I) = RROS(I)*MMPIN
  912 IF (IDEBUG .EQ. ON)  WRITE (6,9997) LOOP
 9997 FORMAT('0','DEBUG - - LOOP = ',I5)
C
      IF (IDEBUG .EQ. ON)  CALL ERDBUG(RROS,TMBLSZ)
      WRITE(DSNROS)  (RROS(I),I=1,TMBLSZ)
      DO 920 I=1,TMBLSZ
  920    RROS(I) = 0.0
      NRROS = 0
C
  922 NRROS = NRROS+1
  924 RROS(NRROS) = ROS
      LASTRD = LOOP
      IF (NRROS .LT. TMBLSZ)  GO TO 942
      IF (OUTPUT .EQ. ENGL)  GO TO 932
      DO 930 I=1,TMBLSZ
  930    RROS(I) = RROS(I)*MMPIN
  932 IF (IDEBUG .EQ. ON)  WRITE (6,9997) LOOP
      IF (IDEBUG .EQ. ON)  CALL EROBUG(RROS,TMBLSZ)
      WRITE(DSNROS) (RROS(I),I=1,TMBLSZ)
      DO 940 I=1,TMBLSZ
  940    RROS(I) = 0.0
      NRROS = 0
C
  942 NRROS = NRROS+1
C
C
C
C WBAL - WATER BALANCE IN THE INTERVAL
C TWBAL - ACCUMULATED WATER BALANCE
C
C
 4011 WBAL = (LZS-LZS1+UZS-UZS1+RESS-RESS1)*PA+(SNET-SNET1+SGW-SGW1+
     X         SCEP-SCEP1+SRCH+SRGXT-SRGXT1+RU-PR)
      IF ((WBAL .LE. 0.0001).AND.(WBAL .GE. -0.0001))  WBAL = 0.0
      TWBAL=TWBAL+WBAL
C
      DPS = F1A*PA
      DPST = DPST + DPS
C
C
C                    RESETTING VARIABLES
C
      LZS1=LZS
      UZS1=UZS
      RESS1=RESS
      SCEP1=SCEP
      SRGXT1=SRGXT
      SGW1=SGW
      SNET1=SNET
C
      ASBAS = ASBAS + SBAS
      ASRCH = ASRCH + SRCH
         APR = APR + PRR
         ARU = ARU + RU
         ARUI = ARUI + RUI
         AROS = AROS + ROS
         ARGXT = ARGXT + RGXT
         IF ((NUMI.NE.0).OR.(IMIN.NE.0))  GO TO 148
         AEPIN = AEPIN + EPIN1
         ASNET = ASNET + SNETI
  148 DO 150  I=1,5
         APERCB(I) = APERCB(I) + PERCB(I)
         AROSB(I) = AROSB(I) + ROSB(I)
         AINTF(I) = AINTF(I) + INTF(I)
         AROSIT(I) = AROSIT(I) + ROSINT(I)
  150    CONTINUE
C
      IF (IMIN .NE. 0)  GO TO 155
C                    CALCULATION OF SOIL MOISTURE
C
      DO 51 I=1,5
         SMOIST(IHR,I) = 45302.4*AREA*RESB(I)/M
         UMOIST(IHR,I) = ((UZSB(I)/UZSN)+0.48)/24.0
         IF (UMOIST(IHR,I) .GT. 0.35)  UMOIST(IHR,I)=0.35
   51 CONTINUE
      LMOIST(IHR) = 0.1404*(LZS/LZSN)**2.66
      IF (LMOIST(IHR) .GT. 0.35)  LMOIST(IHR)=0.35
C
  155 CONTINUE
C
```

```
      IF (PRNTKE .EQ. 0)  GO TO 190
C
C                         CUMULATIVE RECORDS
C
      PRTOM = PRTOM + APR
      EPTOM = EPTOM + AEPIN
      RUTOM = RUTOM + ARU
      ROSTOM = ROSTOM + AROS
      RITOM = RITOM + ARUI
      RINTOM = RINTOM + ARGXT
      NEPTOM = NEPTOM + ASNET
      BASTOM = BASTOM + ASBAS
      RCHTOM = RCHTOM + ASRCH
C
        DO 157  I=1,5
          ROBTOM(I) = ROBTOM(I) + AROSB(I)
          ROBTOT(I) = ROBTOT(I) + AROSB(I)
          INFTOM(I) = INFTOM(I) + AINTF(I)
          INFTOT(I) = INFTOT(I) + AINTF(I)
          ROITOM(I) = ROITOM(I) + AROSIT(I)
  157     ROITOT(I) = ROITOT(I) + AROSIT(I)
C
      PRTOT = PRTOT + APR
      EPTOT = EPTOT + AEPIN
      RUTOT = RUTOT + ARU
      ROSTOT = ROSTOT + AROS
      RITOT = RITOT + ARUI
      RINTOT =RINTOT + ARGXT
      NEPTOT = NEPTOT + ASNET
      BASTOT = BASTOT + ASBAS
      RCHTOT = RCHTOT + ASRCH
C
      IF (PRNTKE .EQ. 2)  GO TO 171
      IF (HYCAL.EQ.PROD) GO TO 160
C
C                      OUTPUT FOR HSP LANDS CALIBRATION RUN
C
C
      RU = (RU*AREA*43560.)/(TIMFAC*720.)
      IF (RU.LT.HYMIN .AND. NUTR.EQ.YES) PRU = RU
      IF (RU .LT. HYMIN)  GO TO 170
      QMETRC=RU*.0283
      IF (NUTR .EQ. YES)  GO TO 960
      WRITE (6,379) MNAM(MONTH),DAY,IHR,IMIN
      WRITE (6,378) RU,QMETRC
      GO TO 170
C
C
C                               WRITE NUTRIENT CALIBRATION OUTPUT
C
  960 IF (PRU .LE. HYMIN) GO TO 970
      GO TO 980
  970       WRITE (6,4001)
            IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)  WRITE (6,4002)
            IF (OUTPUT .EQ. METR)  WRITE (6,4003)
            WRITE (6,4004)
  980 IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)
     1      WRITE (6,4901)  MNAM(MONTH), DAY, IHR, IMIN, RU
      IF (OUTPUT .EQ. METR)
     1      WRITE (6,4901)  MNAM(MONTH), DAY, IHR, IMIN, QMETRC
      PRU = RU
      GO TO 170
C
  160 IF (SNOW.EQ.NO .OR. PRINT.NE.DAYS)  GO TO 169
        SUMSNH = SUMSNO
        PXSNH = PXSNO
        SPXH = MELRAD
        RADMEH = RADMED
```

```
         CORMEH = CORMED
         CONMEH = CONMED
         CRAINH = CRAIND
         SGMH = SGMD
         SNEGMH  = SNEGMD
         SEVAPH = SEVAPD
C
C                    OUTPUT FOR HSP LANDS PRODUCTION RUN  AND SUMMARIES
C
  169 IF (OUTPUT.EQ. METR) GO TO 161
      WRITE (6,360)
      WRITE (6,362)
      WRITE (6,363) AROSB,AROS
      WRITE (6,364) AINTF,ARGXT
      WRITE (6,365) ARUI
      WRITE (6,366) AROSIT,ARU
      WRITE (6,380) ASBAS
      WRITE (6,381) ASRCH
      WRITE (6,361) APR,APR,APR,APR,APR,APR
      IF ((SNOW.EQ.NO).OR.(PACK.LE.0.0))  GO TO 181
C                            SNOWMELT OUTPUT
      WRITE (6,478) SUMSNH
      WRITE (6,479) FXSNH
      WRITE (6,480) SPXH
      WRITE (6,481)
      WRITE (6,482) RADMEH
      WRITE (6,483) CONMEH
      WRITE (6,484) CORMEH
      WRITE (6,485) CRAINH
      WRITE (6,486) SGMH
      WRITE (6,487) SNEGMH
      WRITE (6,490) PACK
         COVR = 100.
         IF (PACK .LT. IPACK) COVR = (PACK/IPACK)*100.
         IF (PACK.GT.0.01) GO TO 1078
         COVR=0.0
         SDEN=0.0
 1078 WRITE (6,491) SDEN
      WRITE (6,492) COVR
      WRITE (6,488) SEVAPH
  181 WRITE (6,367)
      WRITE (6,368) AEPIN,AEPIN,AEPIN,AEPIN,AEPIN,AEPIN
      WRITE (6,369) ASNET,ASNET,ASNET,ASNET,ASNET,ASNET
      WRITE (6,383) COVER
      WRITE (6,370)
      WRITE (6,371) UZSB,UZS
      WRITE (6,372) LZS,LZS,LZS,LZS,LZS,LZS
      WRITE (6,373) SGW,SGW,SGW,SGW,SGW,SGW
      WRITE (6,374) SCEP,SCEP,SCEP,SCEP,SCEP,SCEP
      WRITE (6,375) RESB,RESS
      WRITE (6,376) SRGX,SRGXT
      WRITE (6,377) TWBAL
      IF ((SNOW.EQ.YES).AND.(PACK.GT.0.0))  WRITE (6,489) TSNBAL
  161 IF (OUTPUT.EQ. ENGL) GO TO 171
C
C  METRIC CONVERSIONS FOR OUTPUT
      APR   =APR*MMPIN
      ARUS  =ARUS*MMPIN
      ARGXT =ARGXT*MMPIN
      ARUI  =ARUI*MMPIN
      ARU   =ARU*MMPIN
      ASBAS =ASBAS*MMPIN
      ASRCH =ASRCH*MMPIN
      AEPIN =AEPIN*MMPIN
      ASNET =ASNET*MMPIN
      UZSMET=UZS*MMPIN
      LZSMET=LZS*MMPIN
      SGWMET=SGW*MMPIN
      SCEPMT=SCEP*MMPIN
      RESSMT=RESS*MMPIN
      TWBLMT=TWBAL*MMPIN
      SRGXTM=SRGXT*MMPIN
C   SNOW
      IF (SNOW .EQ. NO)  GO TO 163
      SUMSNH = SUMSNF*MMPIN
      PXSNH = PXSNH*MMPIN
      SPXH = SPXH*MMPIN
      RADMEH = RADMEH*MMPIN
      CONMEH = CONMEH*MMPIN
      CORMEH = CORMEH*MMPIN
      CRAINH = CRAINF*MMPIN
      SGMH = SGMH*MMPIN
      SNEGMH = SNEGMH*MMPIN
      PACKML = PACK*MMPIN
      SEVAPH = SEVAPH*MMPIN
      TSNBML = TSNBAL*MMPIN
  163 DO 162 I=1,5
        AROSB(I) =ARCSB(I)*MMPIN
        AINTF(I) =AINTF(I)*MMPIN
        AROSIT(I)=ARCSIT(I)*MMPIN
        UZSBMT(I)=UZSB(I)*MMPIN
        RESBMT(I)=RESB(I)*MMPIN
        SRGXMT(I)=SRGX(I)*MMPIN
  162 CONTINUE
      WRITE (6,400)
      WRITE (6,362)
      WRITE (6,363) AROSB,AROS
      WRITE (6,364) AINTF,ARGXT
      WRITE (6,365) ARUI
      WRITE (6,366) AROSIT,ARJ
      WRITE (6,380) ASBAS
      WRITE (6,381) ASRCH
      WRITE (6,361) APR,APR,APR,APR,APR,APR
      IF (SNOW.EQ.NO .OR. PACK.LE.0.0)  GO TO 182
      WRITE (6,478)  SUMSNH
      WRITE (6,479)  PXSNH
      WRITE (6,480)  SPXH
      WRITE (6,481)
      WRITE (6,482)  RADMEH
      WRITE (6,483)  CONMEH
      WRITE (6,484)  CORMEH
      WRITE (6,485)  CRAINH
      WRITE (6,486)  SGMH
      WRITE (6,487)  SNEGMH
      WRITE (6,490)  PACKML
         COVR = 100.0
         IF (PACK.LT.IPACK)  COVR = (PACK/IPACK)*100.
         IF (PACK.GT.0.01)  GO TO 1079
         COVR = 0.0
         SDEN = 0.0
 1079 WRITE (6,491)  SDEN
      WRITE (6,492)  COVR
      WRITE (6,488)  SEVAPH
  182 WRITE (6,367)
      WRITE (6,368) AEPIN,AEPIN,AEPIN,AEPIN,AEPIN,AEPIN
      WRITE (6,369) ASNET,ASNET,ASNET,ASNET,ASNET,ASNET
      WRITE (6,383) COVER
      WRITE (6,370)
      WRITE (6,371) UZSBMT, UZSMET
      WRITE (6,372) LZSMET, LZSMET, LZSMET, LZSMET, LZSMET, LZSMET
      WRITE (6,373) SGWMET, SGWMET, SGWMET, SGWMET, SGWMET, SGWMET
      WRITE (6,374) SCEPMT, SCEPMT, SCEPMT, SCEPMT, SCEPMT, SCEPMT
      WRITE (6,375) RESBMT, RESSMT
      WRITE (6,376) SRGXMT, SRGXTM
      WRITE (6,377) TWBLMT
      IF (SNOW.EQ.YES .AND. PACK.GT.0.0)  WRITE (6,489)  TSNBML
```

```
C
  171 IF (PRINT.NE.DAYS)  GO TO 170
          SUMSND = 0.0
          PXSND  = 0.0
          MELRAD = 0.0
          RADMED = 0.0
          CDRMED = 0.0
          CONMED = 0.0
          CRAIND = 0.0
          SGMD   = 0.0
          SNEGMD = 0.0
          SEVAPD = 0.0
C
C                         FORMAT STATEMENTS
C
  378 FORMAT ('+',21X,F6.3,2X,F6.3)
  379 FORMAT (' ',A8,1X,I2,2X,I2,':',I2)
  360 FORMAT ('0',8X,'WATER, INCHES')
  362 FORMAT ('0',11X,'RUNOFF')
  363 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  364 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  365 FORMAT (' ',14X,'IMPERVIOUS',59X,F8.3)
  366 FORMAT (' ',14X,'TOTAL',13X,5(F8.3,2X),1X,F8.3)
  380 FORMAT ('0',11X,'BASE FLOW',63X,F8.3)
  381 FORMAT (' ',11X,'GRDWATER RECHARGE',55X,F8.3)
  361 FORMAT ('0',11X,'PRECIPITATION',6X,5(F7.2,3X),1X,F7.2)
  478 FORMAT (' ',14X,'SNOW',65X,F7.2)
  479 FORMAT (' ',14X,'RAIN ON SNOW',57X,F7.2)
  480 FORMAT (' ',14X,'MELT & RAIN',58X,F7.2)
  481 FORMAT ('0',11X,'MELT')
  482 FORMAT (' ',14X,'RADIATION',60X,F7.2)
  483 FORMAT (' ',14X,'CONVECTION',59X,F7.2)
  484 FORMAT (' ',14X,'CONDENSATION',57X,F7.2)
  485 FORMAT (' ',14X,'RAIN MELT',60X,F7.2)
  486 FORMAT (' ',14X,'GROUND MELT',58X,F7.2)
  487 FORMAT (' ',14X,'CUM NEG HEAT',57X,F7.2)
  490 FORMAT ('0',11X,'SNOW PACK',63X,F7.2)
  491 FORMAT (' ',11X,'SNOW DENSITY',60X,F7.2)
  492 FORMAT (' ',11X,'% SNOW COVER',60X,F7.2)
  488 FORMAT ('0',11X,'SNOW EVAP',63X,F7.2)
  367 FORMAT ('0',11X,'EVAPOTRANSPIRATION')
  368 FORMAT (' ',14X,'POTENTIAL',9X,5(F7.2,3X),1X,F7.2)
  369 FORMAT (' ',14X,'NET',15X,5(F7.2,3X),1X,F7.2)
  383 FORMAT (' ',14X,'CROP COVER',59X,F7.2)
  370 FORMAT ('0',11X,'STORAGES')
  371 FORMAT (' ',14X,'UPPER ZONE',8X,5(F8.3,2X),1X,F8.3)
  372 FORMAT (' ',14X,'LOWER ZONE',8X,5(F8.3,2X),1X,F8.3)
  373 FORMAT (' ',14X,'GROUNDWATER',7X,5(F8.3,2X),1X,F8.3)
  374 FORMAT (' ',14X,'INTERCEPTION',6X,5(F8.3,2X),1X,F8.3)
  375 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  376 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  377 FORMAT ('0',11X,'WATER BALANCE=',F8.4)
  489 FORMAT (' ',11X,'SNOW BALANCE= ',F8.4)
  460 FORMAT ('0',8X,'WATER, MILLIMETERS')
 4001  FORMAT  ('0',40X,'|',10X,'DISSOLVED IN WATER',5X,'|'.
     1          6X,'ADSORBED TO SEDIMENT',5X,'|',/,
     2          ' ',4X,'DATE',6X,'TIME',7X,'FLOW   SEDIMENT',
     3          3X,'NO3+NO2',3X,'NH4',5X,'PO4',6X,'CL',
     4          5X,'NH4',3X,'ORG-N',5X,'PO4',3X,'ORG-P',6X,
     5          'TOT-N',3X,'TOT-P')
 4002  FORMAT  (' ',24X,'(CFS)',5X,'(LB)',2X,8(4X,'(LB)'),7X,'(LB)',
     1          4X,'(LB)')
 4003  FORMAT  (' ',24X,'(CMS)',5X,'(KG)',2X,8(4X,'(KG)'),7X,'(KG)',
     1          4X,'(KG)')
 4004  FORMAT  (' ',32X,'(GM/L)',2X,4(2X,'(MG/L)'),4(3X,'(PPM)'),
     1          5X,'(MG/L)',2X,'(MG/L)')
 4901  FORMAT ('0',A8,1X,I2,2X,I2,':',I2,3X,F8.3)
C
```

```
  170 APR = 0.0
      AEPIN = 0.0
      ARU = 0.0
      ARUI = 0.0
      AROS = 0.0
      ARGXT = 0.0
      ASNET = 0.0
      ASBAS = 0.0
      ASRCH = 0.0
      DO 172  I=1,5
         AROSB(I) = 0.0
         AINTF(I) = 0.0
         AROSIT(I) = 0.0
  172    CONTINUE
C
  190 RETURN
      END
C
C
C
C
      SUBROUTINE SEDT(SFLAG)
C
C
C                                     SEDIMENT EROSION MODEL
C
C
      DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
     1 UZSB(5),APERCB(5),RIB(5),ERSN(5),K3(12)
      DIMENSION SRER(5),ROBTOM(5),ROBTOT(5),INFTOM(5),INFTOT(5),
     1 ROITOM(5),ROITOT(5),RXB(5),ERSTOM(5),ERSTOT(5),MNAM(12),RAD(24),
     2 TEMPX(24),WINDX(24),RAIN(288),UZSBMT(5),RESBMT(5),SRGXMT(5),
     3 SRERMT(5)
      DIMENSION AERSN(5),AERSNM(5)
      DIMENSION ISTAR(5)
      DIMENSION LSRO(128),EROS(128),RROS(128)
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1           STEMP(24),UTEMP(24)
C
      COMMON /ALL/ RC,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
     2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
     3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
     4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
     1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
     2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
     4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
     5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
     6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
     7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
     8 MELRAM,RADMEM,CORMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
     9 PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
     * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
     1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
     2 DSNFLO,DSNERS,LSRO,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
C
C   COMMON ALL DECLARATIONS FOR I*2 & R*4
      INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
      REAL  RC,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
     1      UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
     2      LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
C   COMMON LAND DECLARATIONS FOR I*2 & R*4
      INTEGER  DAY,MONTH,DSNROS,DSNFLO,DSNERS,TMBLSZ,NEROS,
     1         NILSRO,NRROS
```

```
      REAL  SEVAPM,SUMSNY,PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,
     1      CRAINY,SNEGMY,SEVAPY,TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,
     2      RXB,RCITOM,PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,
     3      IPACK,TMIN,SUMSNM,PXSNM,XK3,MELRAM,RADMEM,CORMEM,CRAINM,
     4      CONMEM,SGMM,SNEGMM,PRTOT,ERSNTT,PRTOM,ERSNTM,ROTOM,
     5      NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,ROTOT,NEPTOT,
     6      ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     7      UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,
     8      KV,K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,
     9      SCEP1,SRGXT,SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,
     *      METOPT,CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,
     1      TSNOW,PETMIN,RCITOT,INFTOM,INFTOT,ERSTOM,ERSTOT,SRER,
     2      TEMPX,RAD,WINDX,RAIN,LSRO,EROS,RROS
C
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
      INTEGER*4  LCOF
      DOUBLE PRECISION  MNAM
      INTEGER SFLAG
C
      REAL  SRRTMT
      REAL  KGPLB
C
      DATA  ERSNT/0.0/, AERSN/5*0.0/
      DATA  IASTRK/'*'/, IBLANK/' '/
      DATA LASTLP/-1/
C
C  SER = TRANSPORT CAPACITY OF OVERLAND FLOW IN TONS/ACRE
C  ERSN = EROSION REACHING STREAM
C  SRER = FINES DEPOSIT IN TONS/ACRE
C  RER = FINES GENERATED IN INTERVAL
C
C                          ZEROING OF VARIABLES
C
      SRERT = 0.0
      DO 4599 I=1,5
 4599 ISTAR(I) = IBLANK
      ERSNT = 0.0
      RER = 0.0
      CR = COVER
C
C                          SOIL EROSION LOOP
C
C     IF SNOWING (SFLAG=1) NO SOIL FINES GENERATED
      IF (SFLAG .EQ. 1)  GO TO 4399
C
      IF (SNOW.EQ.NO .OR. PACK.LT.0.01)  GO TO 4389
C     INCREASE COVER BY SNOW COVER WHEN RAIN ON SNOW OCCURS
         SCOVER = PACK/IPACK
         IF (SCOVER .GT. 1.0)  SCOVER = 1.0
         CR = COVER + (1.0-COVER)*SCOVER
C
 4389    RER = (1.0 - CR)*KRER*PR**JRER
 4399 DO 4452 I=1,5
            SRER(I) = SRER(I) + RER
         IF ((ROSB(I)+RESB(I)).GT.0.0) GO TO 4444
C
            ERSN(I) = 0.0
            SER = 0.
            GO TO 4446
C
 4444       SER = KSER*(ROSB(I)+RESB(I))**JSER
            IF (SER .LE. SRER(I)) GO TO 4501
            SER = SRER(I)
            ISTAR(I) = IASTRK
C
 4501       ERSN(I) = SER*ROSB(I)/(ROSB(I)+RESB(I))
            SRER(I) = SRER(I) - ERSN(I)
            IF (SRER(I) .LT. 0.) SRER(I) = 0.
C
 4446    AERSN(I) = AERSN(I) + ERSN(I)
 4452    CONTINUE
C
      IF (PRNTKE .EQ. 0)  GO TO 4490
C
         DO 4456  I=1,5
             ERSNT = ERSNT + AERSN(I)*0.2
             SRERT = SRERT + SRER(I)*0.2
             ERSTOM(I) = ERSTOM(I) + AERSN(I)
             ERSTOT(I) = ERSTOT(I) + AERSN(I)
 4456        CONTINUE
C
C                    CUMULATIVE RECORDS
C
      ERSNTM = ERSNTM + ERSNT
      ERSNTT = ERSNTT + ERSNT
C
      IF (PRNTKE .EQ. 2)  GO TO 4487
C
        ERSNTP = 0.0
        ERSNTK = 0.0
        ERSNKM = 0.0
        ERSNCM = 0.0
C
       IF (HYCAL .EQ. PROD)  GO TO 4460
       IF (RU .LT. HYMIN)  GO TO 4487
C
C   CONVERSION OF SEDIMENT LOSS TO LBS., KGS., KGS/MINUTE, AND
C                                     GM/L FOR OUTPUT
C
       ERSNTP = ERSNT*2000.*AREA
       ERSNTK = ERSNTP*.454
       ERSNKM = ERSNTK/TIMFAC
       ERSNCM = ERSNTP*454./(RU*TIMFAC*60.*28.32)
      IF (NUTR .EQ. YES)  GO TO 892
C
       WRITE (6,4484) ERSNTP, ERSNTK, ERSNKM, ERSNCM
      GO TO 893
C
892   IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)  WRITE (6,4902)  ERSNTP
      IF (OUTPUT .EQ. METR)  WRITE (6,4902)  ERSNTK
C
893   IF (HYCAL.EQ.CALB .AND. PEST.EQ.NO .AND. NUTR.EQ.NO)
    1                       WRITE (6,4999) (ISTAR(I),I=1,5)
 4999           FORMAT ('+',74X,5A1)
       GO TO 4487
C
C
C                      PRINTING OF OUTPUT
C
 4460 IF (OUTPUT.EQ. METR) GO TO 4462
      WRITE (6,4480)
      WRITE (6,4481)  (AERSN(I), I=1,5), ERSNT
      WRITE (6,4482)  (SRER(I), I=1,5), SRERT
 4462 IF (OUTPUT.EQ. ENGL) GO TO 4487
      ERSNTI=ERSNT*METOPT*2.471
      SRRTMT=SRERT*METOPT*2.471
      DO 4461 I=1,5
        AERSNM(I)=AERSN(I)*METOPT*2.471
        SRERMT(I)=SRER(I)*METOPT*2.471
 4461 CONTINUE
      WRITE (6,4485)
      WRITE (6,4481) AERSNM, ERSNTI
      WRITE (6,4482) SRERMT, SRRTMT
C
```

```
C                              FORMAT STATEMENTS
C
 4480 FORMAT ('0',8X,'SEDIMENT, TONS/ACRE')
 4481 FORMAT (' ',11X,'ERODED SEDIMENT',4X,5(3X,F7.3),4X,F7.3)
 4482 FORMAT (' ',11X,'FINES DEPOSIT',6X,5(3X,F7.3),4X,F7.3)
 4484 FORMAT ('+',30X,4(2X,F7.2))
 4485 FORMAT ('0',8X,'SEDIMENT, TONNES/HECTARE')
 4902 FORMAT ('+',30X,F8.2)
C
 4487 DO 4489  I=1,5
         AEPSN(I) = 0.0
 4489    CONTINUE
C
 4490 CONTINUE
C
C        STORE EROSION DATA & WRITE TO DISK
C
      IF (DSNERS.EQ.0) GO TO 1010
      IF (EPSNT.EQ.0.) GO TO 1010
      IF (LOOP.EQ.(LASTLP+1)) GO TO 1050
C
C     DATA COMPRESSION PERFORMED - NO ZEROS STORED
C
      IHEAD = -LOOP
      EROS(NEROS) = IHEAD
      IF (NEROS.LT.TMBLSZ) GO TO 1090
      IF (OUTPUT.EQ.ENGL) GO TO 1060
      DO 1070 I = 1,TMBLSZ
 1070    EROS(I) = EROS(I) *METOPT*2.471
 1060 IF(IDEBUG .EQ. ON) WRITE(6,9996) LOOP
 9996 FORMAT('0','DEBUG - - LOOP = ',I5)
      IF(IDEBUG .EQ. ON) CALL ERDBUG(EROS,TMBLSZ)
      WRITE(DSNERS) (EROS(I),I=1,TMBLSZ)
      DO 1080 I = 1,TMBLSZ
1080     EROS(I) = 0.
      NEROS = 0
 1090 NEROS = NEROS + 1
 1050 EROS(NEROS) = ERSNT
      LASTLP = LOOP
      IF (NEROS.LT.TMBLSZ) GO TO 1000
      IF (OUTPUT.EQ.ENGL) GO TO 1020
      DO 1030 I = 1,TMBLSZ
 1030    EROS(I) = EROS(I) *METOPT*2.471
 1020 IF(IDEBUG .EQ. ON) WRITE(6,9996) LOOP
      IF(IDEBUG .EQ. ON) CALL ERDBUG(EROS,TMBLSZ)
      WRITE(DSNERS) (EROS(I),I=1,TMBLSZ)
      DO 1040 I = 1,TMBLSZ
1040     EROS(I) = 0.
      NEROS = 0
 1000 NEROS = NEROS + 1
C
 1010 CONTINUE
      RETURN
      END
C
C
C
C
      SUBROUTINE ERDBUG(EROS,TMBLSZ)
      DIMENSION EROS(128)
      INTEGER TMBLSZ
C
C       THIS PRINTS OUT EROSION FILES
C
      WRITE(6,100)
      KK = 0
      DO 10 I=1,TMBLSZ
         IF(EROS(I).GT.0.) GO TO 10
```

```
                IF (SRER(I) .LT. 0.) SRER(I) = 0.
C
 4446    AERSN(I) = AERSN(I) + ERSN(I)
 4452    CONTINUE
C
      IF (PRNTKE .EQ. 0)  GO TO 4490
C
           DO 4456  I=1,5
              ERSNT = ERSNT + AERSN(I)*0.2
              SRERT = SRERT + SRER(I)*0.2
              ERSTOM(I) = ERSTOM(I) + AERSN(I)
              ERSTOT(I) = ERSTOT(I) + AERSN(I)
 4456         CONTINUE
C
C                          CUMULATIVE RECORDS
C
      ERSNTM = ERSNTM + ERSNT
      ERSNTT = ERSNTT + ERSNT
C
      IF (PRNTKE .EQ. 2)  GO TO 4487
C
        ERSNTP = 0.0
        ERSNTK = 0.0
        ERSNKM = 0.0
        ERSNCM = 0.0
C
       IF (HYCAL .EQ. PROD)  GO TO 4460
       IF (RU .LT. HYMIN)  GO TO 4487
C
C   CONVERSION OF SEDIMENT LOSS TO LBS., KGS., KGS/MINUTE, AND
C                                         GM/L FOR OUTPUT
C
       ERSNTP = ERSNT*2000.*AREA
       ERSNTK = ERSNTP*.454
       ERSNKM = ERSNTK/TIMFAC
       ERSNCM = ERSNTP*454./(RU*TIMFAC*60.*28.32)
      IF (NUTR .EQ. YES)  GO TO 892
C
       WRITE (6,4484) ERSNTP, ERSNTK, ERSNKM, ERSNCM
      GO TO 893
C
892   IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)  WRITE (6,4902)  ERSNTP
      IF (OUTPUT .EQ. METR)  WRITE (6,4902)  ERSNTK
C
893   IF (HYCAL.EQ.CALB .AND. PEST.EQ.NO .AND. NUTR.EQ.NO)
     1                  WRITE (6,4999) (ISTAR(I),I=1,5)
 4999            FORMAT ('+',74X,5A1)
       GO TO 4487
C
C
C                          PRINTING OF OUTPUT
C
 4460 IF (OUTPUT.EQ. METR) GO TO 4462
      WRITE (6,4480)
      WRITE (6,4481)  (AERSN(I), I=1,5), ERSNT
      WRITE (6,4482)  (SRER(I), I=1,5), SRERT
 4462 IF (OUTPUT.EQ. ENGL) GO TO 4487
      ERSNTI=ERSNT*METOPT*2.471
      SRRTMT=SRERT*METOPT*2.471
      DO 4461 I=1,5
        AERSNM(I)=AERSN(I)*METOPT*2.471
        SRERMT(I)=SRER(I)*METOPT*2.471
 4461 CONTINUE
      WRITE (6,4485)
      WRITE (6,4481) AERSNM, ERSNTI
      WRITE (6,4482) SRERMT, SRRTMT
C
```

```
            IF(I.EQ.1) GO TO 20
            J = I - 1
            JJ = KK + 1
            IHEAD = EROS(KK)
            WRITE(6,110) IHEAD
            WRITE(6,120) (EROS(L),L=JJ,J)
   20       KK = I
   10 CONTINUE
      IF(KK.EQ.0) GO TO 30
      IHEAD = EROS(KK)
      WRITE(6,110) IHEAD
   30 KK = KK + 1
      IF(KK.EQ.TMBLSZ) GO TO 40
      WRITE(6,120) (EROS(L),L=KK,TMBLSZ)
  100 FORMAT('0','WRITE TO DISK - EROS')
  110 FORMAT(1X,I5)
  120 FORMAT(1X,10(E10.3,2X),/)
   40 RETURN
      END
C
C
C
C
      SUBROUTINE ADSRB(UZSN,UZF,LZSN,LZF,
     1 K,NI,KGPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     2 APMODE,TPBAL,DEGSCM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     3 DEGLOM,DEGLOT,NIP,NCOM,UIST,TOTPAP,TIMAP,YEARAP,
     4 DESOPP,SURF,SOIL,SOLG)
C
C
C
      IMPLICIT  REAL(L)
C
      DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
     1 UZSB(5),APERCB(5),RIB(5),ERSN(5)
      DIMENSION SPRP(5),UPRP(5),CT(5),ST(5),JFLAG(5),KD(5),
     3 CAD(5),CTU(5),STU(5),KFLAG(5),KDU(5),CADU(5),STSMET(5),SASMET(5),
     4 SCSMET(5),SDSMET(5),UTSMET(5),UASMET(5),UCSMET(5),UDSMET(5)
      DIMENSION SAPS(5),SCPS(5),SPRS(5),SPRO(5),SPR(5),SPS(5),SCSC(5),
     1 SASC(5),SDSC(5),SPOFS(5),ASPR(5),ASPRS(5),ASPRO(5),ASPRP(5)
      DIMENSION UPRI(5),UNFW(5),UDSC(5),UPR(5),UPS(5),UCSC(5),
     1 UASC(5),AUPR(5),ALPRI(5),AUPRP(5),UPRISM(5)
      DIMENSION CTL(5),MFLAG(5),CADL(5),STL(5),KDL(5)
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1          STEMP(24),UTEMP(24)
C
      COMMON /ALL/ RU,HYMIN,PRNTKE,HYCAL,UPST,OUTPUT,TIMFAC,LZS,AREA,
     1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,P3,A,
     2 CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
     3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
     4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      COMMON /PESTC/
     1 STST,PRSTCM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPRLTT,UAS,SPRSTT,UCS,
     4 FROZ,UDS,UPRITM,USTR,UPRITT,UPRIS
C
C   COMMON ALL DECLARATIONS FOR I*2 & R*4
      INTEGER   PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
      REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
     1      UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
     2      LMOIST,UPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
C
      INTEGER TIMAP(12),YEARAP(12)
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
```

```
C
      INTEGER*4  APPCDE,DESORP,SURF,SOIL
C
      REAL   AK, INFW
      REAL  STSTMT, SASTMT, SCSTMT, SDSTMT
      REAL  STSMET, SASMET, SCSMET, SDSMET
      REAL  MMPIN, METOPT
      REAL  NP, KD, CT, ST, CAD
C
      REAL  UTSTMT, LASTMT, UCSTMT, UDSTMT
      REAL  UTSMET, LASMET, UCSMET, UDSMET
      REAL  JNFW, KNFW, UZSN, UZF, LZSN, LZF
      REAL  KDU, CTU, STU, CADU
C
      REAL  LSTRMT, LASMET, LCSMET, LDSMET
      REAL  GSTRMT, GASMET, GCSMET, GDSMET
      REAL  KDL, CTL, STL
C
      REAL  CML,K,PTOT,CADL
      INTEGER  MFLAG, JFLAG, KFLAG
C
      REAL     K,NI,FPLZ,TOTPAP,KOPT,MOPT,TOPT,TMAX,AK,BK,
     2         KGPLB,FPLG,LSTR,LAS,LCS,LDS,GSTR,GAS,
     3         GCS,GDS,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     4         NIP,DEGLOM,DEGLOT,NCOM,UIST,SOLG
      REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
     2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
     3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
     4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
     5 UPRITT,UPRIS(5)
C
      DATA  SPST, SASCT, SCSCT, SPRT, SPRST, SPRTT, SPRPTT/7*0.0/
      DATA  SPRCT, SPRPT/2*0.0/, INFW/0.0/
      DATA  ASPR, ASPRS, ASPRU, ASPRP/20*0.0/
      DATA  SCSC, SPCPS, SDSCT/11*0.0/
C
      DATA  UPST, UASCT, UCSCT, UPRT/4*0.0/
      DATA  UDSCT, UPRPT/2*0.0/, JNFW/5*0.0/, UPRIT/0.0/
      DATA  AUPR, ALPRI, AUPRP/15*0.0/
      DATA  ALPRP/0.0/
C
      DATA  CT/5*0.0/,JFLAG/5*0/,CAD/5*0.0/,ST/5*0.0/
      DATA  CTU/5*0.0/,KFLAG/5*0/,CADU/5*0.0/,STU/5*0.0/
      DATA  CTL/5*0.0/,MFLAG/5*0/,CADL/5*0.0/,STL/5*0.0/,KDL/5*0.0/
      DATA KD,KDU/10*0.0/
C
C
C                         SURFACE SOLUTION ADSORPTION-DESORPTION MODEL
C
C                    ZEROING VARIABLES
C
      STST = 0.0
      SAST = 0.0
      SCST = 0.0
      SDST = 0.0
      EPSNT = 0.0
      ASPTOT = 0.0
C
C                    ADSORPTION-DESORPTION SOLUTION LOOP
C                       WITH REVERSIBLE DESORPTION
C
      PA = 1.0 - A
      Z = 1000000.**(NI-1)
      KK = M*K*Z
      DO 5320  I=1,5
        INFW = 0.2*AREA*(P3+RESB1(I))*226512.
        PTOT = SAS(I) + SCS(I) + SDS(I) + SSTR1(I)
        ASPTOT = ASPTOT + PTOT
```

```
         IF (PTOT.GT.FP) GO TO 5315
            SAS(I) = PTOT
            SCS(I) = 0.0
            SDS(I) = 0.0
            JFLAG(I) = 0
            CT(I) = C
            GO TO 5320
 5315    X = KK*CMAX**NI + FP
         PSLD = PTOT - X - INFW*CMAX
         IF (PSLD .LT. 0.0)  GO TO 5316
            SAS(I) = X
            SCS(I) = PSLD
            SDS(I) = CMAX*INFW
            JFLAG(I) = 0
            CT(I) = C
            GO TO 5320
C
 5316       SCS(I) = 0.0
            IF (INFW.GE.0.001) GO TO 5321
            SAS(I) = PTOT
            SDS(I) = 0.0
            JFLAG(I) = 0
            CT(I) = C
            GO TO 5320
C
C          COMPUTE C AND X BY THE ADSORPTION EQUATION
C
 5321       C = CMAX*PTOT/(X + INFW*CMAX)
 5317       X = KK*C**NI + FP
            Q = (PTOT/(X+INFW*C)) - 1.
            IF (ABS(Q).LE.0.01) GO TO 5319
               C = C*PTOT/(X + INFW*C)
               GO TO 5317
C
 5319          IF (DESORP .EQ. NO)  GO TO 5324
C
      CALL DSPTN (I,CT,C,JFLAG,CAD,KD,K,Z,NCUM,
     1            ST,X,M,NIP,FP,PTOT,INFW)
C
 5324          SDS(I) = (C*INFW)*(PTOT/(X+C*INFW))
               SAS(I) = X*(PTOT/(X+C*INFW))
C
 5320    CONTINUE
C
C                   PESTICIDE REMOVAL LOOP
C
      DO 5330  I=1,5
C
         QS = 400.*AREA*ERSN(I)/M
         IF (QS .GT. 1.0)  QS = 1.0
         SAPS(I) = SAS(I)*QS
         SCPS(I) = SCS(I)*QS
         SPRS(I) = SAPS(I) + SCPS(I)
         SAS(I) = SAS(I) - SAPS(I)
         SCS(I) = SCS(I) - SCPS(I)
C
            SPRO(I) = 0.0
            SPOFS(I) = 0.0
            SPRP(I) = 0.0
            SPR(I) = 0.0
         IF (P3 +RESB1(I).LE.0.0) GO TO 5329
            SPRO(I) = SDS(I)*ROSB(I)/((RESB1(I)+P3)*PA)
C
         SPOFS(I) = SCS(I)*(RESB(I)/(RESB1(I)+P3))
         SPRP(I) = SCS(I) - SPRO(I) - SPOFS(I)
         SPR(I) = SPRO(I) + SPRS(I) + SPRP(I)
 5329    SDS(I) = SPOFS(I)
C
```

```
         ASPR(I) = ASPR(I) + SPR(I)
         ASPRS(I) = ASPRS(I) + SPRS(I)
         ASPRO(I) = ASPRO(I) + SPRO(I)
         ASPRP(I) = ASPRP(I) + SPRP(I)
C
C
         RESBI(I) = 0.0
C
 5330    CONTINUE
C
      IF (PRNTKE .EQ. 0)  GO TO 5390
C
C                    PREPARATION OF OUTPUT
C
         DO 5335  I=1,5
            SPRT = SPRT +ASPR(I)
            SPROT = SPROT +ASPRO(I)
            SPRST = SPRST +ASPRS(I)
            SPRPT = SPRPT +ASPRP(I)
C
            SAST = SAST + SAS(I)
            SCST = SCST + SCS(I)
            SDST = SDST + SDS(I)
C
            SASC(I) = (SAS(I)/M)*1000000.
            SASCT = SASCT + SASC(I)*0.2
            SCSC(I) = (SCS(I)/M)*1000000.
            SCSCT = SCSCT + SCSC(I)*0.2
            SDSC(I) = (SDS(I)/M)*1000000.
            SDSCT = SDSCT + SDSC(I)*0.2
C
            STS(I) = SAS(I) + SCS(I) + SDS(I)
            SPS(I) = SASC(I) + SCSC(I) + SDSC(I)
            STST = STST + STS(I)
            SPST = SPST + SPS(I)*0.2
C
            ERSNT = ERSNT + ERSN(I)*0.2*AREA
C
 5335       CONTINUE
C
C                    CUMULATIVE RESULTS
         DO 5337  I= 1,5
            PRSTOM(I) = PRSTOM(I) + ASPRS(I)
            PROTOM(I) = PROTOM(I) + ASPRO(I)
            PROTOT(I) = PROTOT(I) + ASPRO(I)
 5337       PRSTOT(I) = PRSTOT(I) + ASPRS(I)
C
         SPROTM = SPROTM + SPROT
         SPRSTM = SPRSTM + SPRST
C
         SPRTT = SPRTT + SPRT
         SPROTT = SPROTT + SPROT
         SPRPTT = SPRPTT + SPRPT
         SPRSTT = SPRSTT + SPRST
C
      IF (PRNTKE .EQ. 2)  GO TO 5370
         IF (HYCAL .EQ. PROD)  GO TO 5340
         IF (RJ .LT. HYMIN)  GO TO 5370
            SPRTGW = SPROT*454.
            SPRTCW = (SPROT/(RU*TIMFAC*60.*62.43))*1000000.
            SPRTGS = SPRST*454.
            SPRTCS = 0.0
            IF (ERSNT.GT.0.0)  SPRTCS = (SPRST/(ERSNT*2000.))*1000000.
            GO TO 5370
C                    PRINTING OF OUTPUT
C
 5340 IF (OUTPUT.EQ. METR) GO TO 5341
      WRITE (6,5350)
      WRITE (6,5351)  STS, STST
      WRITE (6,5352)  SAS, SAST
      WRITE (6,5353)  SCS, SCST
      WRITE (6,5361) SDS, SDST
      WRITE (6,5354)  SPS, SPST
      WRITE (6,5352)  SASC, SASCT
      WRITE (6,5353)  SCSC, SCSCT
      WRITE (6,5361)  SDSC, SDSCT
      WRITE (6,5355)  ASPR, SPRT
      WRITE (6,5356)  ASPRS, SPRST
      WRITE (6,5357)  ASPRO, SPROT
      WRITE (6,5359)  ASPRP, SPRPT
 5341 IF (OUTPUT.EQ. ENGL) GO TO 5370
C
C  METRIC CONVERSIONS FOR OUTPUT
      STSTMT=STST*KGPLB
      SASTMT=SAST*KGPLB
      SCSTMT=SCST*KGPLB
      SDSTMT=SDST*KGPLB
      SPRT  =SPRT*KGPLB
      SPRST =SPRST*KGPLB
      SPROT =SPROT*KGPLB
      SPRPT =SPRPT*KGPLB
      DO 5343 I=1,5
        STSMET(I)=STS(I)*KGPLB
        SASMET(I)=SAS(I)*KGPLB
        SCSMET(I)=SCS(I)*KGPLB
        SDSMET(I)=SDS(I)*KGPLB
        ASPR(I)  =ASPR(I)*KGPLB
        ASPRS(I) =ASPRS(I)*KGPLB
        ASPRO(I) =ASPRO(I)*KGPLB
        ASPRP(I) =ASPRP(I)*KGPLB
 5343 CONTINUE
      WRITE (6,5350)
      WRITE (6,5363) STSMET, STSTMT
      WRITE (6,5352) SASMET, SASTMT
      WRITE (6,5353) SCSMET, SCSTMT
      WRITE (6,5361) SDSMET, SDSTMT
      IF (OUTPUT.EQ. BOTH) GO TO 5345
      WRITE (6,5354)  SPS, SPST
      WRITE (6,5352)  SASC, SASCT
      WRITE (6,5353)  SCSC, SCSCT
      WRITE (6,5361)  SDSC, SDSCT
 5345 WRITE (6,5374) ASPR,SPRT
      WRITE (6,5356)  ASPRS, SPRST
      WRITE (6,5357)  ASPRO, SPROT
      WRITE (6,5359)  ASPRP, SPRPT
C
C
C                         ZEROING VARIABLES
C
 5370 DO 5380  I=1,5
          ASPR(I) = 0.0
          ASPRO(I) = 0.0
          ASPRS(I) = 0.0
          ASPRP(I) = 0.0
 5380    CONTINUE
C
 5390 SPST = 0.0
      SASCT = 0.0
      SCSCT = 0.0
      SDSCT = 0.0
      SPRT = 0.0
      SPRST = 0.0
      SPROT = 0.0
      SPRPT = 0.0
C
      DO 5391  I= 1,5
 5391 SSTR1(I) = 0.0
C
C
C
C                        UPPER ZONE SOLUTION ADSORPTION-DESORPTION MODEL
C
C
C                     ZEROING VARIABLES
C
      UTST = 0.0
      UAST = 0.0
      UCST = 0.0
      UDST = 0.0
      UIST = 0.0
      AUPTOT = 0.0
C
C                     SOLUTION ADSORPTION-DESORPTION LOOP
C
C  45302.4 = 0.2 * 43560 FT(2)/ACRE * 1 FT/12 INCHES * 62.4 LB/FT(3)
C
      KK = MUZ*K*Z
C
      DO 6320  I=1,5
         JNFW(I) = AREA*PA*(UZSB(I)+APERCB(I)+INFL(I)+RGX(I))*45302.4
         PTOT = UAS(I) + UCS(I) + UDS(I) + SPRP(I) + USTR(I)
         AUPTOT = AUPTOT + PTOT
         CS = 0.0
         IF (JNFW(I) .GT. 0.0)  CS = UDS(I)/JNFW(I)
C
         IF (PTOT.GT.FPUZ) GO TO 6315
            UAS(I) = PTOT
            UCS(I) = 0.0
            UDS(I) = 0.0
            KFLAG(I) = 0
            CTU(I) = C
            GO TO 6320
C
 6315    X = KK*CMAX**NI + FPUZ
         PSLD = PTOT - X - JNFW(I)*CMAX
         IF (PSLD .LT. 0.0)  GO TO 6316
            UAS(I) = X
            UCS(I) = PSLD
            UDS(I) = CMAX*JNFW(I)
            KFLAG(I) = 0
            CTU(I) = C
            GO TO 6320
C
 6316       UCS(I) = 0.0
C
            C = CS
            IF (C .LE. 0.0)  C = 0.001
 6317       X = KK*C**NI + FPUZ
            Q = (PTOT/(X+JNFW(I)*C)) - 1.
            IF (ABS(Q).LE.0.01) GO TO 6319
               C = C*PTOT/(X+JNFW(I)*C)
               GO TO 6317
C
 6319          IF (JNFW(I) .LE. 0.001)  X = PTOT
               IF (DESORP .EQ. NO)  GO TO 6324
                  RJNFW = JNFW(I)
C
      CALL DSPTN (I,CTU,C,KFLAG,CADJ,KDU,K,Z,NCOM,
     1             STC,X,MUZ,NIP,FPUZ,PTOT,RJNFW)
C
 6324          UDS(I) = (C*JNFW(I))*(PTOT/(X+C*JNFW(I)))
               UAS(I) = X*(PTOT/(X+C*JNFW(I)))
C
 6320    CONTINUE
```

```
      C
      C                       PESTICIDE REMOVAL LOOP
      C
      C  UZFM REDUCES SOLUTE PERCOLATION FOR SOIL MOISTURE LESS THAN UZF*UZSN
      C
            DO 6330  I=1,5
      C
               IF (JNFW(I) .LE. 0.0001)  GO TO 6327
               QSP = AREA*PA*(INFL(I)+APERCB(I))*45302.4/JNFW(I)
               UZFM = UZSB(I)/(UZSN*UZF)
               IF (UZFM.GE.1.0) UZFM = 1.0
               UPRP(I) = UDS(I)*QSP*UZFM
               IF (SRGX(I)+INTF(I) .LT. 0.0001)  GO TO 6329
               QSI = AREA*PA*45302.4*RGX(I)/JNFW(I)
               UPRII = UDS(I)*QSI
               UPRIS(I) = UPRIS(I) + UPRII
               UPRI(I)  = UPRIS(I)*INTF(I)/(SRGX(I)+INTF(I))
               UPRIS(I) = UPRIS(I) - UPRI(I)
               GO TO 6328
       6327    UPRP(I) = 0.0
       6329    UPRII = 0.0
               UPRI(I) = 0.0
       6328    UDS(I) = UDS(I) - UPRP(I) - UPRII
               UPR(I) = UPRP(I) + UPRI(I)
      C
               AUPR(I) = AUPR(I) + UPR(I)
               AUPRI(I) = AUPRI(I) + UPRI(I)
               AUPRP(I) = AUPRP(I) + UPRP(I)
               UIST = UIST + UPRIS(I)
      C
       6330    CONTINUE
      C
            IF (PRNTKE .EQ. 0)  GO TO 6380
      C
      C                       PREPARATION OF OUTPUT
      C
               DO 6335  I=1,5
                  UPRT = UPRT + AUPR(I)
                  UPRIT = UPRIT + AUPRI(I)
                  UPRPT = UPRPT + AUPRP(I)
      C
                  UAST = UAST + UAS(I)
                  UCST = UCST + UCS(I)
                  UDST = UDST + UDS(I)
      C
                  UASC(I) = (UAS(I)/MUZ)*1000000.
                  UCSC(I) = (UCS(I)/MUZ)*1000000.
                  IF (UZSB(I) .LE. 0.0001)  GO TO 6333
                  UDSC(I) = (UDS(I)/(UZSB(I)*AREA*45302.4))*1000000.
                  GO TO 6334
       6333       UDSC(I) = 0.0
       6334       UPS(I) = UASC(I) + UCSC(I) + UDSC(I)
      C
                  UASCT = UASCT + UASC(I)*0.2
                  UCSCT = UCSCT + UCSC(I)*0.2
                  UDSCT = UDSCT + UDSC(I)*0.2
                  UPST = UPST + UPS(I)*0.2
      C
                  UTS(I) = UAS(I) + UCS(I) + UDS(I) + UPRIS(I)
                  UTST = UTST + UTS(I)
      C
       6335       CONTINUE
      C
      C                       CUMULATIVE RESULTS
      C
               DO 6340  I= 1,5
                  UPITOM(I) = UPITOM(I) + AUPRI(I)
       6340       UPITOT(I) = UPITOT(I) + AUPRI(I)
      UPRITM = UPRITM + UPRIT
      UPRITT = UPRITT + UPRIT
C
      IF (PRNTKE .EQ. 2)  GO TO 6365
C
      IF (HYCAL .EQ. PROD) GO TO 6341
      IF (RU.LT.HYMIN) GO TO 6365
         UPRTGW = UPRIT*454.
         UPRTCW = 1000000.*UPRIT/(RU*TIMFAC*60.*62.43)
         TPRTGW = UPRTGW + SPRTGW
         TPRTCW = UPRTCW + SPRTCW
         TPRTGM = TPRTGW/TIMFAC
         SPRTGM = SPRTGS/TIMFAC
      WRITE (6,6460) TPRTGW,TPRTGM,TPRTCW,SPRTGS,SPRTGM,SPRTCS
      GO TO 6365
C
C                       PRINTING OF OUTPUT
C
 6341 IF (OUTPUT.EQ. METR) GO TO 6342
      WRITE (6,6350)
      WRITE (6,5351)  UTS, UTST
      WRITE (6,5352)  UAS, UAST
      WRITE (6,5353)  UCS, UCST
      WRITE (6,5361)  UDS, UDST
      WRITE (6,6362)  UPRIS, UIST
      WRITE (6,5354)  UPS, UPST
      WRITE (6,5352)  UASC, UASCT
      WRITE (6,5353)  UCSC, UCSCT
      WRITE (6,5361)  UDSC, UDSCT
      WRITE (6,5355)  AUPR, UPRT
      WRITE (6,6358)  AUPRI, UPRIT
      WRITE (6,5359)  AUPRP, UPRPT
 6342 IF (OUTPUT.EQ. ENGL) GO TO 6365
C
C  METRIC CONVERSIONS FOR OUTPUT
      UTSTMT=UTST*KGPLB
      UASTMT=UAST*KGPLB
      UCSTMT=UCST*KGPLB
      UDSTMT=UDST*KGPLB
      UPRT  =UPRT*KGPLB
      UPRIT =UPRIT*KGPLB
      UPRPT =UPRPT*KGPLB
      UIST = UIST*KGPLB
      DO 6344 I=1,5
        UTSMET(I)=UTS(I)*KGPLB
        UASMET(I)=UAS(I)*KGPLB
        UCSMET(I)=UCS(I)*KGPLB
        UDSMET(I)=UDS(I)*KGPLB
        AUPR(I)  =AUPR(I)*KGPLB
        AUPRI(I) =AUPRI(I)*KGPLB
        AUPRP(I) =AUPRP(I)*KGPLB
        UPRISM(I)=UPRIS(I)*KGPLB
 6344 CONTINUE
      WRITE (6,6350)
      WRITE (6,5363) UTSMET, UTSTMT
      WRITE (6,5352) UASMET, UASTMT
      WRITE (6,5353) UCSMET, UCSTMT
      WRITE (6,5361) UDSMET, UDSTMT
      WRITE (6,6362) UPRISM, UIST
      IF (OUTPUT.EQ. BOTH) GO TO 6345
      WRITE (6,5354)  UPS, UPST
      WRITE (6,5352)  UASC, UASCT
      WRITE (6,5353)  UCSC, UCSCT
      WRITE (6,5361)  UDSC, UDSCT
 6345 WRITE (6,5374) AUPR, UPRT
      WRITE (6,6358)  AUPRI, UPRIT
      WRITE (6,5359)  AUPRP, UPRPT
```

```
C
C
C                               ZEROING VARIABLES
C
 6365 DO 6370  I=1,5
          AUPR(I) = 0.0
          AUPRI(I) = 0.0
          AUPRP(I) = 0.0
 6370     CONTINUE
C
 6380 UPST = 0.0
      UASCT = 0.0
      UCSCT = 0.0
      UDSCT = 0.0
      UPRT = 0.0
      UPRPT = 0.0
      UPRIT = 0.0
C
      DO  6381  I= 1,5
 6381 USTR(I) = 0.0
C
C
C
C                                             LOWER ZONE AND GROUNDWATER
C                                             SOLUTION ADSORPTION-DESORPTION MODEL
C
C
C
C
C                               SOLUTION ADSORPTION-DESORPTION LOOP
C
      LCS = 0.0
      LAS = 0.0
      LDS = 0.0
      LPRP = 0.0
      ALPTOT = 0.0
C
      KNFW = AREA*(LZS+UPST)*226512.
      KK = KLZ*K*Z
C
      DO 7305  I=1,5
         LSTF = LSTR + UPRP(I)
         ALPTOT = ALPTOT + LSTR
 7305    CONTINUE
C
         IF (LSTR .LE. 0.0001)  GO TO 7330
C
      I=1
      PTOT = LSTR
      CS = 0.0
      IF (KNFW .GT. 0.0)  CS = LAS/KNFW
      IF (PTOT.GT.FPLZ) GO TO 7315
         LAS = PTOT
         LCS = 0
         LDS = 0
         MFLAG(I) = 0
         CTL(I) = 0
         GO TO 7320
C
 7315 X = KK*CMAX**NI + FPLZ
      PSLD = PTOT - X - KNFW*CMAX
      IF (PSLD .LT. 0.0)  GO TO 7316
         LAS = X
         LCS = PSLD
         LDS = CMAX*KNFW
         MFLAG(I) = 0
         CTL(I) = 0
         GO TO 7320
```

```
C
 7316    LCS = 0.0
C
         C = C5
         IF (C .LE. 0.0)  C = 0.001
 7317    X = KK*C**NI + FPLZ
         Q = (PTOT/(X+KNFW*C)) - 1.
         IF (ABS(Q).LE.0.01) GO TO 7319
            C = C*PTOT/(X+KNFW*C)
            GO TO 7317
C
 7319 IF (KNFW .LE. 0.001)  X = PTOT
      IF (DESORP .EQ. NO) GO TO 7324
C
      CALL DSPTN (I,CTL,C,MFLAG,CADL,KDL,K,Z,NCOM,
     1               STL,X,MLZ,NIP,FPLZ,PTOT,KNFW)
C
 7324   LDS = (C*KNFW)*(PTOT/(X+C*KNFW))
            LAS = X*(PTOT/(X+C*KNFW))
C
 7320    CONTINUE
C
C                       PESTICIDE REMOVAL LOOP
C
C  LZFM REDUCES SOLUTE PERCOLATION FOR SOIL MOISTURE LESS THAN LZF*LZSN
C
      LZFM = LZS/(LZSN*LZF)
      IF (LZFM.GE.1.0) LZFM =1.0
      LPRP = LDS*DPST*LZFM/(DPST+LZS)
      LDS = LDS - LPRP
C
      LSTR = LAS + LCS + LDS
C
      ALPRP = ALPRP + LPRP
C
 7330 IF (PRNTKE .EQ. 2)  GO TO 7379
      IF (PRNTKE.NE.1 .OR. HYCAL.EQ.CALB)  GO TO 7380
C
C                       PREPARATION OF OUTPUT
C
C
      LASC = (LAS/MLZ)*1000000.
      LCSC = (LCS/MLZ)*1000000.
      LDSC = (LDS/(LZS*AREA*226512.))*1000000.
C
C                        PRINTING OF OUTPUT
C
      IF (OUTPUT.EQ. METR) GO TO 7340
      WRITE (6,7350)
      WRITE (6,7351)  LSTR
      WRITE (6,7352)  LAS
      WRITE (6,7353)  LCS
      WRITE (6,7354)  LDS
      WRITE (6,7355)
      WRITE (6,7352)  LASC
      WRITE (6,7353)  LCSC
      WRITE (6,7354)  LDSC
      WRITE (6,7357)  ALPRP
      WRITE (6,7359)  ALPRP
 7340 IF (OUTPUT.EQ. ENGL) GO TO 7379
C
C  METRIC CONVERSIONS FOR OUTPUT
      LSTRMT=LSTR*KGPLB
      LASMET=LAS*KGPLB
      LCSMET=LCS*KGPLB
      LDSMET=LDS*KGPLB
      ALPRP =ALPRP*KGPLB
      WRITE (6,7350)
      WRITE (6,7360) LSTRMT
      WRITE (6,7352) LASMET
      WRITE (6,7353) LCSMET
      WRITE (6,7354) LDSMET
      IF (OUTPUT.EQ. BOTH) GO TO 7345
      WRITE (6,7355)
      WRITE (6,7352)  LASC
      WRITE (6,7353)  LCSC
      WRITE (6,7354)  LDSC
 7345 WRITE (6,7361) ALPRP
      WRITE (6,7359) ALPRP
C
C
C                    ZEROING OF VARIABLES
C
 7379 ALPRP = 0.0
C
 7380 CONTINUE
C
C  SULG IS THE SUMMATION OF PESTICIDE IN STORAGE IN THE SURFACE,
C   UPPER, AND LOWER ZONES (IT DOES NOT INCLUDE PESTICIDE IN
C   GROUNDWATER STORAGE) AND IS USED AS A CHECK IN MAIN TO DECIDE
C   WHETHER OR NOT TO CONTINUE PESTICIDE CALCULATIONS
C
      SULG = ASPTOT + AUPTOT + ALPTOT
C
C
C                                GROUNDWATER ADSORPTION-DESORPTION MODEL
C
C
      GSTR = GSTR + LPRP
      IF (FPLZ .GT. 0.0)  GO TO 7520
         GAS = 0.0
         GDS = GSTR
         GCS = 0.0
C
 7520    GAS = GSTR
         GCS = 0.0
         GDS = 0.0
C
      IF ((PRNTKE .NE. 1).OR.(HYCAL.EQ.CALB))  GO TO 7580
C
C                    PRINTING OF OUTPUT
C
      IF (OUTPUT.EQ. METR) GO TO 7530
      WRITE (6,7550)
      WRITE (6,7351)  GSTR
      WRITE (6,7352)  GAS
      WRITE (6,7353)  GCS
      WRITE (6,7354)  GDS
 7530 IF (OUTPUT.EQ. ENGL) GO TO 7580
C
C  METRIC CONVERSIONS FOR OUTPUT
      GSTRMT=GSTR*KGPLB
      GASMET=GAS*KGPLB
      GCSMET=GCS*KGPLB
      GDSMET=GDS*KGPLB
      WRITE (6,7550)
      WRITE (6,7360) GSTRMT
      WRITE (6,7352) GASMET
      WRITE (6,7353) GCSMET
      WRITE (6,7354) GDSMET
C
 7580 CONTINUE
C
C                    FORMAT STATEMENTS
C
```

```
 5350 FORMAT  ('0', 5X,'SURFACE LAYER PESTICIDE')
 5351 FORMAT  ('0',8X,'PESTICIDE, LBS',8X,5(3X,F7.3),3X,F8.3)
 5352 FORMAT  (' ',11X,'ADSORBED',11X,5(3X,F7.3),3X,F8.3)
 5353 FORMAT  (' ',11X,'CRYSTALLINE',8X,5(3X,F7.3),3X,F8.3)
 5354 FORMAT  ('0',8X,'PESTICIDE, PPM',8X,5(3X,F7.3),3X,F8.3)
 5355 FORMAT  ('0',8X,'REMOVAL, LBS',10X,5(3X,F7.3),3X,F8.3)
 5356 FORMAT  (' ',11X,'SEDIMENT',11X,5(3X,F7.3),3X,F8.3)
 5357 FORMAT  (' ',11X,'OVERLAND FLOW',6X,5(3X,F7.3),3X,F8.3)
 5359 FORMAT  (' ',11X,'PERCOLATION',8X,5(3X,F7.3),3X,F8.3)
 5361 FORMAT (' ',11X,'DISSOLVED',10X,5(3X,F7.3),3X,F8.3)
 5363 FORMAT ('0',8X,'PESTICIDE, KGS',8X,5(3X,F7.3),3X,F8.3)
 5374 FORMAT ('0',8X,'REMOVAL, KGS',10X,5(3X,F7.3),3X,F8.3)
C
 6350 FORMAT  ('0', 5X,'UPPER ZONE LAYER PESTICIDE')
 6358 FORMAT  (' ',11X,'INTERFLOW',10X,5(3X,F7.3),3X,F8.3)
 6362 FORMAT  (' ',11X,'INTERFLOW STORAGE',2X,5(2X,F8.3),3X,F8.3)
 6460 FORMAT  ('+',72X,2(3X,F8.3,2X,F8.3,2X,F7.3))
C
 7350 FORMAT  ('0', 5X,'LOWER ZONE LAYER PESTICIDE')
 7351 FORMAT  ('0',8X,'PESTICIDE, LBS',61X,F8.3)
 7352 FORMAT  (' ',11X,'ADSORBED',64X,F8.3)
 7353 FORMAT  (' ',11X,'CRYSTALLINE',61X,F8.3)
 7354 FORMAT  (' ',11X,'DISSOLVED',63X,F8.3)
 7355 FORMAT  ('0',8X,'PESTICIDE, PPM',61X,F8.3)
 7357 FORMAT  ('0',8X,'REMOVAL, LBS',63X,F8.3)
 7359 FORMAT  (' ',11X,'PERCOLATION',61X,F8.3)
 7360 FORMAT  ('0',8X,'PESTICIDE, KGS',61X,F8.3)
 7361 FORMAT  ('0',8X,'REMOVAL, KGS',63X,F8.3)
C
 7550 FORMAT  ('0',5X,'GROUNDWATER LAYER PESTICIDE')
      RETURN
      END
C
C
C
C
      SUBROUTINE DSPTN (I,CT,C,JFLAG,CAD,KD,K,Z,NCOM,
     1                  ST,X,M,NIP,FP,PTOT,INFW)
C
C
C
      DIMENSION CT(5),JFLAG(5),CAD(5),KD(5),ST(5)
C
      INTEGER I,JFLAG
      REAL CT,C,CAD,KD,K,Z,NCOM,ST,X,M,NIP,FP,PTOT,INFW
C
C  THE DESORPTION ALGORITHM IS BASED ON THE FREUNDLICH EQUATION; THE
C  DIFFERENCE BEING THAT THE CONSTANT (K) AND EXPONENT (N) OF THE
C  DESORPTION EQUATION DIFFER FROM THE ADSORPTION VALUES.  DESORPTION
C  OCCURS WHEN THE CONCENTRATION OF PESTICIDE IN WATER (C) IS LESS THAN
C  THE CONCENTRATION (CT) AT THE LAST TIME STEP.  THE DESORPTION
C  EXPONENT (NP -- INPUTTED BY THE USER) AND THE DESORPTION CONSTANT
C  (KD -- CALCULATED BY SETTING THE DESORPTION EQUATION EQUAL TO THE
C  ADSORPTION EQUATION AND SOLVING FOR KD) THEN DEFINE THE NEW DESORP-
C  TION CURVE.  THE ASSUMPTION OF REVERSIBLE DESORPTION IS MADE.  ONCE
C  DESORPTION STOPS ADSORPTION BEGINS BY MOVING BACK UP THE DESORPTION
C  CURVE UNTIL IT INTERSECTS THE ADSORPTION CURVE (I.E., WHEN C EQUALS
C  CAD -- THE CONCENTRATION OF PESTICIDE IN WATER AT WHICH THE ADSORP-
C  TION AND DESORPTION CURVES INTERSECT).  THEN ADSORPTION CONTINUES UP
C  THE ADSORPTION CURVE UNTIL DESORPTION OCCURS AGAIN.  DEFINTIONS OF
C  THE DESORPTION VARIABLES FOLLOW BELOW.
C
C          CT  :  CONCENTRATION OF PESTICIDE IN WATER (LB/LB)
C                   AT THE LAST TIME INTERVAL
C          CAD  :  CONCENTRATION C AT WHICH THE ADSORPTION AND
C                    DESORPTION EQUATIONS MEET, CAD IS SET
C                    EQUAL TO CT WHEN DESORPTION BEGINS AS A
C                    MARKER TO LATER DETERMINE WHEN THE ADSORP-
```

```
C                       TION PROCESS LEAVES THE REVERSIBLE DESORP-
C                       TION CURVE AND RETURNS TO THE NON-REVERSIBLE
C                       ADSORPTION CURVE
C              ST   :  CONCENTRATION OF ADSORBED PESTICIDE IN THE SOIL
C                       (LB/LB) AT THE LAST TIME INTERVAL
C              JFLAG  :  FLAG WHICH NOTES WHETHER C WAS CALCULATED ON THE
C                          ADSORPTION CURVE DURING LAST TIME STEP (JFLAG=0)
C                          OR ON THE DESORPTION CURVE (JFLAG=1)
C              NP   :  DESORPTION EXPONENT, APPROXIMATELY 2.3 TIMES N
C                       (INPUTTED BY USER)
C              NIP  :  INVERSE OF NP
C              KD   :  DESORPTION CONSTANT FOR FREUNDLICH CURVE
C              NCOM  :  RATIO OF NIP TO NI
C
C
      IF (CT(I).LE.C) GO TO 5396
      IF (JFLAG(I).EQ.1) GO TO 5393
C
      CAD(I) = CT(I)
      KD(I) = ((K*Z)**NCOM)*(ST(I)**(1.-NCOM))
 5393 X = M*KD(I)*(C**NIP) + FP
      Q = (PTOT/(X+INFW*C)) - 1.0
      IF (ABS(Q).LE.0.01) GO TO 5395
      C = C*PTOT/(X+INFW*C)
      GO TO 5393
C
 5395 JFLAG(I) = 1
      CT(I) = C
      GO TO 5398
C
 5396 IF (JFLAG(I).EQ.0) GO TO 5397
      IF (C.LT.CAD(I)) GO TO 5393
C
 5397 JFLAG(I) = 0
      CT(I) = C
      ST(I) = X/M
      CAD(I) = C
C
 5398 RETURN
      END
C
C
C
C
                    SUBROUTINE DEGRAD(
     1 K,NI,KOPLB,FPLZ,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     2 APMODE,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     3 DEGLOM,DEGLOT,NIP,NCOM,UIST,TOTPAP,TIMAP,YEARAP,
     4 DESORP,SURF,SOIL,SOLG,DEGCON)
C
C
C                              DEGRADATION MODEL
C
C
C
C
      DIMENSION RESB(5),RESB1(5),ROSB(5),SRGX(5),INTF(5),RGX(5),INFL(5),
     1 UZSB(5),APERCB(5),RIB(5),ERSN(5)
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1          STEMP(24),UTEMP(24)
C
      COMMON /ALL/ RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1 RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,M,PS,A,
     2 CALB,PROJ,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,IMIN,IHR,TF,
     3 JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,ON,OFF,
     4 SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      COMMON /PESTC/
     1 STST,PRSTCM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITCM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
     4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
C
C   COMMON ALL DECLARATIONS FOR I*2 & R*4
       INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT,IDEBUG
       REAL  RU,HYMIN,LZS,AREA,RESB1,ROSB,SRGX,INTF,RGX,INFL,
      1       UZSB,APERCB,RIB,ERSN,M,P3,A,RESB,SMOIST,UMOIST,
      2       LMOIST,DPST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
C
        REAL  MMPIN,METOPT,LMAVG
       INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
      1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
       INTEGER*4  APMCDE,DESCRP,SURF,SOIL
C
        INTEGER TIMAP(12),YEARAP(12)
        REAL   K,NI,FPLZ,TOTPAP,DEGCON,
     2         KGPLB,FPLG,LSTR,LAS,LCS,LDS,GSTR,GAS,
     3         GCS,GDS,TPBAL,DEGSOM,DEGSOT,DEGUOM,DEGUOT,DEGU,DEGS,
     4         NIP,DEGLOM,DEGLOT,NCOM,JIST,SOLG
       REAL  STST,PRSTCM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
     2 PROTOT(5),SCST,UPITCM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
     3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
     4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
     5 UPRITT,UPRIS(5)
C
C
C                            DEGRADATION OF PESTICIDE FROM ADSORBED (A),
C                            CRYSTALLINE (C), AND DISSOLVED (D) FORMS
C                            DEGCON = FIRST ORDER DECAY RATE (PER DAY)
C
C
C                INITIALIZE PARAMETERS
      DEGS = 0.0
      DEGU = 0.0
      DEGL = 0.0
C
C                                DEGRADATION OF PESTICIDE
C
C                        SURFACE ZONE
C
      IF (STST .LE. 0.0)  GO TO 8022
      STST = 0.0
      DO 8020 I=1,5
         DEGSA = DEGCON*SAS(I)
         SAS(I) = SAS(I) - DEGSA
         SAST = SAST - DEGSA
         DEGSC = DEGCON*SCS(I)
         SCS(I) = SCS(I) - DEGSC
         SCST = SCST - DEGSC
         DEGSD = DEGCON*SDS(I)
         SDS(I) = SDS(I) - DEGSD
         SDST = SDST - DEGSC
         DEGS = DEGS + DEGSA + DEGSC + DEGSD
         STS(I) = SAS(I) + SCS(I) + SDS(I)
         STST = STST + STS(I)
 8020 CONTINUE
C
C                        UPPER ZONE
C
 8022 IF (UTST .LE. 0.0)  GO TO 8026
      UTST = 0.0
      DO 8024 I=1,5
         DEGUA = DEGCON*UAS(I)
         UAS(I) = UAS(I) - DEGUA
```

```
                UAST = UAST - DEGUA
                DEGUC = DEGCON*UCS(I)
                UCS(I) = UCS(I) - DEGUC
                UCST = UCST - DEGUC
                DEGUD = DEGCON*UDS(I)
                UDS(I) = UDS(I) - DEGUD
                UDST = UDST - DEGUD
                DEGU = DEGU + DEGUA + DEGUC + DEGUD
                UTS(I) = UAS(I) + UCS(I) + UDS(I) + UPRIS(I)
                UTST = UTST + UTS(I)
 8024 CONTINUE
C
C                           LOWER ZONE
C
 8026 IF (LSTR .LE. 0.0)  GO TO 8090
      DEGLA = DEGCON*LAS
      LAS = LAS - DEGLA
      DEGLC = DEGCON*LCS
      LCS = LCS - DEGLC
      DEGLD = DEGCON*LDS
      LDS = LDS - DEGLD
      DEGL = DEGLA + DEGLC + DEGLD
      LSTR = LAS + LCS + LDS
C
 8090       CONTINUE
C
C
C
C                     CUMULATIVE RESULTS
C
      DEGSOM = DEGSOM + DEGS
      DEGSOT = DEGSOT + DEGS
      DEGUOM = DEGUOM + DEGU
      DEGUOT = DEGUOT + DEGU
      DEGLOM = DEGLOM + DEGL
      DEGLOT = DEGLOT + DEGL
C
      TDEG = DEGS + DEGU + DEGL
C
          IF ((PRNTKE .NE. 1).OR.(HYCAL.EQ.CALB))  GO TO 8600
C
      IF (OUTPUT.EQ. METR) GO TO 8200
         WRITE (6,8505)
         WRITE (6,8501) TDEG
         WRITE (6,8502) DEGS
         WRITE (6,8503) DEGU
         WRITE (6,8507) DEGL
 8200 IF (OUTPUT.EQ. ENGL) GO TO 8600
C
C  METRIC CONVERSIONS FOR OUTPUT
      TDEGMT=TDEG*KGPLB
      DEGSMT=DEGS*KGPLB
      DEGUMT=DEGU*KGPLB
      DEGLMT=DEGL*KGPLB
      WRITE (6,8506)
      WRITE (6,8501) TDEGMT
      WRITE (6,8502) DEGSMT
      WRITE (6,8503) DEGUMT
      WRITE (6,8507) DEGLMT
C
C
 8501 FORMAT (' ',8X,'TOTAL',71X,F7.3)
 8502 FORMAT (' ',8X,'FROM SURFACE',64X,F7.3)
 8503 FORMAT (' ',8X,'FROM UPPER ZONE',61X,F7.3)
 8505 FORMAT ('0',5X,'PESTICIDE DEGRADATION LOSS, LBS.')
 8506 FORMAT ('0',5X,'PESTICIDE DEGRADATION LOSS, KGS.')
 8507 FORMAT (' ',8X,'FROM LOWER ZONE',61X,F7.3)
C
```

```
 8600 RETURN
      END
C
C
C
C
C
      SUBROUTINE NUTRIO (IOERR,INTRVL,NAPP,SNAPL,UNAPL,TIMHR,
     1                   INPUT,OUTPUT,APDAY,KNI,KPI,ULUPF,LZUPF)
C
C                             THIS SUBROUTINE READS NUTRIENT INPUT SEQ.
C                             FOR REACTION RATES, INITIAL STORAGES, AND
C                             APPLICATIONS.  INPUT INFORMATION IS SCANNED
C                             FOR ERRORS WHICH ARE FLAGGED BY IOERR=1.
C                             ON RETURN TO MAIN IOERR=1 WILL STOP THE RUN
C
C                             SUBROUTINE ALSO OUTPUTS REACTION RATES,
C                             INITIAL STORAGES, AND APPLICATIONS
C
C                             DECLARATIONS
C
C                             COMMON VARIABLES
C
      INTEGER   TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      REAL  DELT,
     1         SNT(20),SNRSM(20,5),SNROM(20,5),
     2         UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
     3         NRSM(20,5),LNRPM(20),
     4         SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
     5         SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
     6         LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
     7         TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
     8         KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
      DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,UN,UNT,UNI,UNIT,
     1            UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2            SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3            TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4            KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5            TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
C
      INTEGER   NAPPL,NAPP,TIMHAR,TIMHR
      INTEGER*4   INPUT,OUTPUT
C
      INTEGER   NSTRT,NEND,APDAY(5),IOERR,ICHK,IZONE,IBLK,J,
     1            IAPFL
C
      REAL  SNAPL(20,5,5),SNAPLT(20),UNAPL(20,5,5),UNAPLT(20),
     1        TNMET,TPMET,TCLMET,KNI(8,4),KPI(5,4),ULUPTK(12),
     2        LZUPTK(12),LZUPF(12),ULUPF(12)
C
      DOUBLE PRECISION  CONC, LBPAC, KGPHA, NTRT, CHAR8, BLANK8
C
C
C                  DATA INPUT -- NAMELIST VARIABLES
C
C         NAMELIST IS SUPPORTED ON ONLY IBM COMPUTERS.  TO USE
C     NAMELIST REMOVE C FROM COLUMN 1 IN THE FOLLOWING NAMELIST
C     READ STATEMENTS.  ADD C TO COLUMN 1 IN THE FORMATTED READ
C     STATEMENTS TO DEACTIVATE THAT SECTION OF CODE.
C
C
      NAMELIST /NUTRIN/ TSTEP,NAPPL,TIMHAR
      NAMELIST /PLANTU/ ULUPTK
      NAMELIST /PLANTL/ LZUPTK
C
```

```
C
C                             CHARACTER STRINGS USED TO COMPARE AND
C                             INTERPRET INPUT SEQUENCE, NAMES OF
C                             REACTION RATES, AND INPUT UNITS OPTION.
C
      INTEGER*4  CHAR,TYPE,BLANK,REAC,NITR,PHOS,CHLO,END,SURF,
     1       UPPE,LOWE,GROU,TEMP,INIT,APPL,METR,ENGL,
     2       KNNAME(8), KPNAME(5)
C
C                             INITIALIZATION OF STORAGES AND FLAGS
C
      DATA LBPAC/'LB/AC'/,KGPHA/'KG/HA'/,NTRT/'NUTRIENT'/
      DATA BLANK8/'        '/, BLANK/'    '/, REAC/'REAC'/
      DATA NITR/'NITR'/,PHOS/'PHOS'/,CHLO/'CHLO'/,END/'END '/
      DATA SURF/'SURF'/,UPPE/'UPPE'/,LOWE/'LOWE'/,GROU/'GROU'/
      DATA TEMP/'TEMP'/,INIT/'INIT'/,APPL/'APPL'/,METR/'METR'/
      DATA ENGL/'ENGL'/
      DATA KNNAME/'  KI', '  KD', ' KPL', ' KAM',
     1            ' KIM', 'KKIM', ' KSA', ' KAS'/
      DATA KPNAME/'  KM', ' KIM', ' KPL', ' KSA', 'KAS'/
      IDERR = 0
      SFLG = 1
      UFLG = 1
      LFLG = 1
      GFLG = 1
      DO 130  J=1,20
         DO 120  IBLK=1,5
            SN(J,IBLK) = 0.0
            UN(J,IBLK) = 0.0
            UNI(J,IBLK) = 0.0
  120    CONTINUE
         LN(J) = 0.0
         GN(J) = 0.0
  130 CONTINUE
      DO 135  IZONE=1,4
         DO 132  J=1,8
            KNI(J,IZONE) = 0.0
  132    CONTINUE
         DO 134  J=1,5
            KPI(J,IZONE) = 0.0
  134    CONTINUE
  135 CONTINUE
C
C
  136 READ (5,3001)  CHAR8
      WRITE (6,7777) CHAR8
 7777 FORMAT (' ',A8)
      IF (CHAR8 .EQ. BLANK8)  GO TO 136
      IF (CHAR8 .EQ. NTRT)  GO TO 142
         IDERR = 1
         WRITE (6,4555)  CHAR8
         RETURN
C
C
C                       DATA INPUT -- NAMELIST VARIABLES
C
C          NAMELIST IS SUPPORTED ON ONLY IBM COMPUTERS.  TO USE
C     NAMELIST REMOVE C FROM COLUMN 1 IN THE FOLLOWING NAMELIST
C     READ STATEMENTS.  ADD C TO COLUMN 1 IN THE THREE FORMATTED
C     READ STATEMENTS (DIRECTLY BELOW) TO DEACTIVATE THAT
C     SECTION OF CODE.
C
C
  142 READ (5,NUTRIN)
      READ (5,PLANTU)
      READ (5,PLANTL)
C
C142  READ (5,3002) TSTEP,NAPPL,TIMAP
```

```
C     READ (5,5001) (ULUPTK(I),I=1,12)
C     READ (5,5001) (LZUPTK(I),I=1,12)
C
C          THE FOLLOWING ASSIGNMENT IS DUE TO THE NAMELIST LISTS
C       OF ULUPTK AND LZUPTK NOT BEING ABLE TO BE USED IN AN ARGUMENT
C       LIST BEFORE BEING READ IN A NAMELIST.
C
      DO 143 J=1,12
         ULUPF(J) = ULUPTK(J)
         LZUPF(J) = LZUPTK(J)
143   CONTINUE
C
      WRITE (6,4600)
      WRITE (6,4005)
      WRITE (6,4005)
      WRITE (6,4610)  TSTEP,NAPPL,TIMHAR,ULUPTK,LZUPTK
      NAPP=NAPPL
      TIMHR = TIMHAR
C
C                             CHECK TSTEP TO SEE IF AN INTEGER NUMBER ARE
C                             IN A DAY (1440 MIN) AND CHECK THAT TSTEP IS
C                             AN INTEGER MULTIPLE OF THE SIMULATION
C                             INTERVAL (5 OR 15 MIN).
C                             DELT IS THE TIME STEP IN HOURS BECAUSE
C                             REACTION RATES ARE PER HOUR (INTERNALLY).
C
      ICHK = 0
      ITSTEP=TSTEP
      IF ( MOD(1440,ITSTEP) .NE. 0)  ICHK=1
      IF ( MOD(ITSTEP,INTRVL) .NE. 0)  ICHK=1
      IF (ICHK .EQ. 0)  GO TO 145
         WRITE (6,4770) TSTEP
         TSTEP = 60
145   DELT = TSTEP/60.
      NSTEP = 1440/TSTEP
C
C
C                             INPUT REACTION RATES
C
C
150   READ (5,3000)  CHAR
      IF (CHAR .EQ. BLANK)  GO TO 150
      IF (CHAR .EQ. REAC)  GO TO 160
         IDERR = 1
         WRITE (6,4619)
         WRITE (6,4630)  REAC, CHAR
         RETURN
160   READ (5,3000)  TYPE
      IF (TYPE .EQ. BLANK)  GO TO 160
      IF (TYPE .EQ. NITR)  GO TO 170
      IF (TYPE .EQ. PHOS)  GO TO 220
      IF (TYPE .EQ. END)  GO TO 300
         IDERR = 1
         WRITE (6,4619)
         WRITE (6,4640)  TYPE
         RETURN
C
C                             NITROGEN RATES
C
170   READ (5,3000)  CHAR
      IF (CHAR .EQ. SURF)  GO TO 180
         IDERR = 1
         WRITE (6,4620)  TYPE
         WRITE (6,4630)  SURF, CHAR
         RETURN
180   READ (5,3010)  (RNI(J,1),J=1,8)
C
      READ (5,3000)  CHAR
```

```
          IF (CHAR .EQ. UPPE)  GO TO 190
             IDERR = 1
             WRITE (6,4620)  TYPE
             WRITE (6,4630)  UPPE, CHAR
             RETURN
  190     READ (5,3010)  (KNI(J,2),J=1,8)
C
          READ (5,3000)  CHAR
          IF (CHAR .EQ. LOWE)  GO TO 200
             IDERR = 1
             WRITE (6,4620)  TYPE
             WRITE (6,4630)  LOWE, CHAR
             RETURN
  200     READ (5,3010)  (KNI(J,3),J=1,8)
C
          READ (5,3000)  CHAR
          IF (CHAR .EQ. GROU)  GO TO 205
             IDERR = 1
             WRITE (6,4620)  TYPE
             WRITE (6,4630)  GROU, CHAR
             RETURN
  205     READ (5,3010)  (KNI(J,4),J=1,8)
C
          READ (5,3000)  CHAR
          IF (CHAR .EQ. TEMP)  GO TO 210
             IDERR = 1
             WRITE (6,4620)  TYPE
             WRITE (6,4630)  TEMP, CHAR
             RETURN
  210     READ (5,3010)  (THAN(J),J=1,8)
          GO TO 100
C
C                                    PHOSPHORUS RATES
C
  220     READ (5,3000)  CHAR
          IF (CHAR .EQ. SURF)  GO TO 230
             IDERR = 1
             WRITE (6,4620)  TYPE
             WRITE (6,4630)  SURF, CHAR
             RETURN
  230     READ (5,3010)  (KPI(J,1),J=1,5)
C
          READ (5,3000)  CHAR
          IF (CHAR .EQ. UPPE)  GO TO 240
             IDERR = 1
             WRITE (6,4620)  TYPE
             WRITE (6,4630)  UPPE, CHAR
             RETURN
  240     READ (5,3010)  (KPI(J,2),J=1,5)
C
          READ (5,3000)  CHAR
          IF (CHAR .EQ. LOWE)  GO TO 250
             IDERR = 1
             WRITE (6,4620)  TYPE
             WRITE (6,4630)  LOWE, CHAR
             RETURN
  250     READ (5,3010)  (KPI(J,3),J=1,5)
C
          READ (5,3000)  CHAR
          IF (CHAR .EQ. GROU)  GO TO 260
             IDERR = 1
             WRITE (6,4620)  TYPE
             WRITE (6,4630)  GROU, CHAR
             RETURN
  260     READ (5,3010)  (KPI(J,4),J=1,5)
C
          READ (5,3000)  CHAR
          IF (CHAR .EQ. TEMP)  GO TO 270
```

```
                  IOERR = 1
                  WRITE (6,4620)  TYPE
                  WRITE (6,4630)  TEMP, CHAR
                  RETURN
      270   READ (5,3010)  (THKP(J),J=1,5)
            GO TO 160
      C
      C                            OUTPUT OF REACTION RATES AND TEMPERATURE
      C                            CORRECTION FACTORS.
      C
      300   WRITE (6,4650)  (KNNAME(J),J=1,8),
           1                ((KNI(J,IZONE),J=1,8),IZONE=1,4),(THKN(J),J=1,8)
            WRITE (6,4660)  (KPNAME(J),J=1,5),
           1                ((KPI(J,IZONE),J=1,5),IZONE=1,4),(THKP(J),J=1,5)
      C
      C                            CONVERT RATES FROM PER DAY TO PER HOUR, AND
      C                            CHECK REACTION RATES BY ZONE FOR
      C                            1) REASONABLENESS, I.E. >= 0.0
      C                            2) VALIDITY OF NUMERICAL SOLUTION TECHNIQUE
      C                               THE EXPRESSION KNI(J,IZONE)*DELT IS THE
      C                               FRACTION OF THE CONSTITUTENT REMOVED
      C                               DURING THE TIMESTEP.  THIS NUMBER SHOULD
      C                               BE MUCH LESS THAN 1. FOR ACCURATE SOLUTION
      C                               CHECK SET AT 0.5.
      C                            3) ON OR OFF, IF KNI AND KPI ARE ALL ZERO FOR
      C                               A ZONE, THEN NO TRANSFORMATIONS ARE DONE.
      C                               S,U,L, AND GFLG ARE FLAGS TO INDICATE
      C                               IF TRANSFORMATIONS ARE DONE (1) OR NOT(0).
      C
            DO 311  IZONE=1,4
               SUM = 0.0
               DO 303  J=1,8
                  KNI(J,IZONE) = KNI(J,IZONE)/24.
                  IF (KNI(J,IZONE) .GE. 0.0)  GO TO 301
                     IOERR = 1
                     WRITE (6,4780)  KNNAME(J), IZONE, KNI(J,IZONE)
                     RETURN
      301         IF (DELT*KNI(J,IZONE) .LT. 0.5)  GO TO 302
                     WRITE (6,4790)  KNNAME(J), IZONE
      302         SUM = SUM + KNI(J,IZONE)
      303      CONTINUE
               DO 306  J=1,5
                  KPI(J,IZONE) = KPI(J,IZONE)/24.
                  IF (KPI(J,IZONE) .GE. 0.0)  GO TO 304
                     IOERR = 1
                     WRITE (6,4800)  KPNAME(J), IZONE, KPI(J,IZONE)
                     RETURN
      304         IF (DELT*KPI(J,IZONE) .LT. 0.5)  GO TO 305
                     WRITE (6,4810)  KPNAME(J), IZONE
      305         SUM = SUM + KPI(J,IZONE)
      306      CONTINUE
               IF (SUM .LT. 0.00001)  GO TO (307,308,309,310), IZONE
                  GO TO 311
      307      SFLG = 0
                  GO TO 311
      308      UFLG = 0
                  GO TO 311
      309      LFLG = 0
                  GO TO 311
      310      GFLG = 0
      311   CONTINUE
            DO 313  J=1,8
               IF (THKN(J) .GE. 1.0)  GO TO 313
                  WRITE (6,4812)  KNNAME(J)
      313   CONTINUE
            DO 314  J=1,5
               IF (THKP(J) .GE. 1.0)  GO TO 314
                  WRITE (6,4814)  KPNAME(J)
```

```
314   CONTINUE
C
C
C                               INPUT OF INITIAL NUTRIENT STORAGES
C
C
319   READ (5,3000)  CHAR
      IF (CHAR .EQ. BLANK)  GO TO 319
      IF (CHAR .EQ. INIT)  GO TO 320
         IOERR = 1
         WRITE (6,4665)  CHAR
         RETURN
320   READ (5,3000)  TYPE
      IF (TYPE .EQ. BLANK)  GO TO 320
      IF (TYPE .EQ. NITR)  GO TO 330
      IF (TYPE .EQ. PHOS)  GO TO 340
      IF (TYPE .EQ. CHLO)  GO TO 350
      IF (TYPE .EQ. END)  GO TO 560
         IOERR = 1
         WRITE (6,4725)
         WRITE (6,4740)  TYPE
         RETURN
330   NSTRT = 1
      NEND = 6
         GO TO 360
340   NSTRT = 11
      NEND = 14
         GO TO 360
350   NSTRT = 20
      NEND = 20
C
C                                   SURFACE
C
360   READ (5,3020)  CHAR, NBLK
      IF (CHAR .EQ. SURF)  GO TO 365
         IOERR = 1
         WRITE (6,4670)  TYPE
         WRITE (6,4630)  SURF, CHAR
         RETURN
365   IF (NBLK.EQ.0 .OR. NBLK.EQ.1 .OR. NBLK.EQ.5)  GO TO 370
         IOERR = 1
         WRITE (6,4670)  TYPE
         WRITE (6,4650)  SURF, NBLK
         RETURN
370   IF (NBLK .EQ. 5)  GO TO 400
      READ (5,3010)  (SNT(J),J=NSTRT,NEND)
      DO 390  J=NSTRT,NEND
         DO 380  IBLK=1,5
            SN(J,IBLK) = SNT(J)
380      CONTINUE
390   CONTINUE
      GO TO 440
C
400   DO 410  IBLK=1,5
         READ (5,3010)  (SN(J,IBLK),J=NSTRT,NEND)
410   CONTINUE
      DO 430  J=NSTRT,NEND
         SUM = 0.0
         DO 420  IBLK=1,5
            SUM = SUM + SN(J,IBLK)
420      CONTINUE
         SNT(J) = SUM/5.
430   CONTINUE
C
C                                   UPPER ZONE
C
440   READ (5,3020)  CHAR, NBLK
      IF (CHAR .EQ. UPPE)  GO TO 450
```

```
                 IDERR = 1
                 WRITE (6,4070) TYPE
                 WRITE (6,4630)  UPPE, CHAR
                 RETURN
      450   IF (NBLK.EQ.0 .OR. NBLK.EQ.1 .OR. NBLK.EQ.5)  GO TO 460
                 IDERR = 1
                 WRITE (6,4070)  TYPE
                 WRITE (6,4050)  UPPE, NBLK
                 RETURN
      460   IF (NBLK .EQ. 5)  GO TO 490
            READ (5,3010)  (UNT(J),J=NSTRT,NEND)
            DO 480  J=NSTRT,NEND
               DO 470  IBLK=1,5
                  UN(J,IBLK) = UNT(J)
      470      CONTINUE
      480   CONTINUE
            GO TO 530
      C
      490   DO 500  IBLK=1,5
               READ (5,3010)  (UN(J,IBLK),J=NSTRT,NEND)
      500   CONTINUE
            DO 520  J=NSTRT,NEND
               SUM = 0.0
               DO 510  IBLK=1,5
                  SUM = SUM + UN(J,IBLK)
      510      CONTINUE
               UNT(J) = SUM/5.
      520   CONTINUE
      C
      C                               LOWER ZONE
      C
      530   READ (5,3000)  CHAR
            IF (CHAR .EQ. LOWE)  GO TO 540
               IDERR = 1
               WRITE (6,4070)  TYPE
               WRITE (6,4030)  LOWE, CHAR
               RETURN
      540   READ (5,3010)  (LN(J),J=NSTRT,NEND)
      C
      C                               GROUNDWATER
      C
            READ (5,3000)  CHAR
            IF (CHAR .EQ. GROU)  GO TO 550
               IDERR = 1
               WRITE (6,4070)  TYPE
               WRITE (6,4630)  GROU, CHAR
               RETURN
      550   READ (5,3010)  (GN(J),J=NSTRT,NEND)
      C
            GO TO 320
      C
      C                               OUTPUT OF INITIAL NUTRIENT STORAGES
      C
      560   WRITE (6,4005)
            WRITE (6,4005)
      C
            CONC = LBPAC
            IF (INPUT .EQ. METR)  CONC=KGPHA
            WRITE (6,4000)  CONC
            WRITE (6,4700)
            WRITE (6,4010)
            WRITE (6,4025)  (SNT(J),J=1,6),(SNT(J),J=11,14),SNT(20)
            WRITE (6,4030)  (IBLK,(SN(J,IBLK),J=1,6),(SN(J,IBLK),J=11,14),
          1                 SN(20,IBLK),  IBLK=1,5)
            WRITE (6,4090)
            WRITE (6,4025)  (UNT(J),J=1,6),(UNT(J),J=11,14),UNT(20)
            WRITE (6,4030)  (IBLK,(UN(J,IBLK),J=1,6),(UN(J,IBLK),J=11,14),
          1                 UN(20,IBLK),  IBLK=1,5)
      WRITE (6,4110)
      WRITE (6,4020)  (LN(J),J=1,6),(LN(J),J=11,14),LN(20)
      WRITE (6,4120)
      WRITE (6,4020)  (GN(J),J=1,6),(GN(J),J=11,14),GN(20)
C
C                         CONVERSION OF METRIC INPUT TO ENGLISH (LB/AC)
C
      IF (INPUT .EQ. ENGL)  GO TO 573
      DO 570  J=1,20
         DO 565  IBLK=1,5
            SN(J,IBLK) = SN(J,IBLK)*.8924
            UN(J,IBLK) = UN(J,IBLK)*.8924
565      CONTINUE
         LN(J) = LN(J)*.8924
         GN(J) = GN(J)*.8924
570   CONTINUE
C
C                        COMPUTE TOTAL NITROGEN (TNA), TOTAL PHOSPHORUS
C                        (TPA), AND TOTAL CHLORIDE (TCLA) IN THE SYSTEM
C                         UNITS = LB/AC.
C
573   TNA = 0.0
      DO 575  J=1,6
         SUM = 0.0
         DO 574  IBLK=1,5
            SUM = SUM + SN(J,IBLK) + UN(J,IBLK)
574      CONTINUE
         TNA = TNA + LN(J) + GN(J) + SUM/5.
575   CONTINUE
C
      TPA = 0.0
      DO 585  J=11,14
         SUM = 0.0
         DO 580  IBLK = 1,5
            SUM = SUM + SN(J,IBLK) + UN(J,IBLK)
580      CONTINUE
         TPA = TPA + LN(J) + GN(J) + SUM/5.
585   CONTINUE
C
      TCLA = 0.0
      DO 590  IBLK=1,5
         TCLA = TCLA + SN(20,IBLK) + UN(20,IBLK)
590   CONTINUE
      TCLA = LN(20) + GN(20) + TCLA/5.
C
      IF (INPUT .EQ. METR)  GO TO 595
         CONC = LBPAC
         WRITE (6,4820)  TNA,CONC, TPA,CONC, TCLA,CONC
      GO TO 600
595      CONC = KGPHA
         TNMET = TNA*1.121
         TPMET = TPA*1.121
         TCLMET = TCLA*1.121
         WRITE (6,4820)  TNMET,CONC, TPMET,CONC, TCLMET,CONC
C
C
C                             NUTRIENT APPLICATIONS
C
C
600   IF (NAPPL.GE.0 .AND. NAPPL.LE.5)  GO TO 610
         IOERR = 1
         WRITE (6,4710)  NAPPL
         RETURN
610   IF (NAPPL .EQ. 0)  GO TO 910
C
      CONC = LBPAC
      IF (INPUT .EQ. METR)  CONC=KGPHA
      WRITE (6,4000)  CONC
      C
            DO 900  IAPPL=1,NAPPL
               DO 614  J=1,20
                  SNAPLT(J) = 0.0
                  UNAPLT(J) = 0.0
                  DO  612  IBLK=1,5
                     SNAPL(J,IBLK,IAPPL) = 0.0
                     UNAPL(J,IBLK,IAPPL) = 0.0
      612         CONTINUE
      614      CONTINUE
      C
      620      READ (5,3020)  CHAR, APDAY(IAPPL)
               IF (CHAR .EQ. BLANK)  GO TO 620
               IF (CHAR .EQ. APPL)  GO TO 630
                  IOERR = 1
                  WRITE (6,4720)
                  WRITE (6,4630)  APPL, CHAR
                  RETURN
      630      IF (APDAY(IAPPL).GE.0 .AND. APDAY(IAPPL).LE.366)  GO TO 635
                  IOERR = 1
                  WRITE (6,4720)
                  WRITE (6,4730)  IAPPL, APDAY(IAPPL)
                  RETURN
      635      IF (IAPPL .EQ. 1)  GO TO 640
               IF (APDAY(IAPPL) .GT. APDAY(IAPPL-1))  GO TO 640
                  IOERR = 1
                  WRITE (6,4720)
                  WRITE (6,4735)  IAPPL
                  RETURN
      640      READ (5,3000)  TYPE
               IF (TYPE .EQ. BLANK)  GO TO 640
               IF (TYPE .EQ. NITR)  GO TO 650
               IF (TYPE .EQ. PHOS)  GO TO 660
               IF (TYPE .EQ. CFLO)  GO TO 670
               IF (TYPE .EQ. END)  GO TO 870
                  IOERR = 1
                  WRITE (6,4720)
                  WRITE (6,4745)  TYPE, IAPPL
                  RETURN
      650      NSTRT = 1
               NEND = 6
                  GO TO 680
      660      NSTRT = 11
               NEND = 14
                  GO TO 680
      670      NSTRT = 20
               NEND = 20
      C
      C                              SURFACE
      C
      680      READ (5,3020)  CHAR, NBLK
               IF (CHAR .EQ. SURF)  GO TO 690
                  IOERR = 1
                  WRITE (6,4720)
                  WRITE (6,4750)  IAPPL, TYPE, SURF, CHAR
                  RETURN
      690      IF (NBLK.EQ.0 .OR. NBLK.EQ.1 .OR. NBLK.EQ.5)  GO TO 700
                  IOERR = 1
                  WRITE (6,4720)
                  WRITE (6,4690)  SURF, NBLK
                  RETURN
      700      IF (NBLK .EQ. 5)  GO TO 730
               READ (5,3010)  (SNAPLT(J),J=NSTRT,NEND)
               DO 720  J=NSTRT,NEND
                  DO 710  IBLK=1,5
                     SNAPL(J,IBLK,IAPPL) = SNAPLT(J)
      710         CONTINUE
      720      CONTINUE
```

Reproduced from
best available copy.

```
            GO TO 770
      C
      730   DO 740  IBLK=1,5
               READ (5,3010)  (SNAPL(J,IBLK,IAPPL),J=NSTRT,NEND)
      740   CONTINUE
            DO 760  J=NSTRT,NEND
               SUM = 0.0
               DO 750  IBLK=1,5
                  SUM = SUM + SNAPL(J,IBLK,IAPPL)
      750      CONTINUE
               SNAPLT(J) = SUM/5.
      760   CONTINUE
      C
      C                              UPPER ZONE
      C
      770   READ (5,3020)  CHAR, NBLK
            IF (CHAR .EQ. UPPE)  GO TO 780
               IOERR = 1
               WRITE (6,4720)
               WRITE (6,4750)  IAPPL, TYPE, SURF, CHAR
               RETURN
      780   IF (NBLK.EQ.0 .OR. NBLK.EQ.1 .OR. NBLK.EQ.5)  GO TO 790
               IOERR = 1
               WRITE (6,4720)
               WRITE (6,4690)  UPPE, NBLK
               RETURN
      790   IF (NBLK .EQ. 5)  GO TO 820
            READ (5,3010)  (UNAPLT(J),J=NSTRT,NEND)
            DO 810  J=NSTRT,NEND
               DO 800  IBLK=1,5
                  UNAPL(J,IBLK,IAPPL) = UNAPLT(J)
      800      CONTINUE
      810   CONTINUE
            GO TO 860
      C
      820   DO 830  IBLK=1,5
               READ (5,3010)  (UNAPL(J,IBLK,IAPPL),J=NSTRT,NEND)
      830   CONTINUE
            DO 850  J=NSTRT,NEND
               SUM = 0.0
               DO 840  IBLK=1,5
                  SUM = SUM + UNAPL(J,IBLK,IAPPL)
      840      CONTINUE
               UNAPLT(J) = SUM/5.
      850   CONTINUE
      860   GO TO 640
      C
      C                              OUTPUT OF NUTRIENT APPLICATIONS
      C
      870   WRITE (6,4760)  APDAY(IAPPL)
            WRITE (6,4010)
            WRITE (6,4025) (SNAPLT(J),J=1,6),(SNAPLT(J),J=11,14),SNAPLT(20)
            WRITE (6,4030)  (IBLK,(SNAPL(J,IBLK,IAPPL),J=1,6),
           1                 (SNAPL(J,IBLK,IAPPL),J=11,14),
           2                 SNAPL(20,IBLK,IAPPL),  IBLK=1,5)
      C
            WRITE (6,4050)
            WRITE (6,4025) (UNAPLT(J),J=1,6),(UNAPLT(J),J=11,14),UNAPLT(20)
            WRITE (6,4030)  (IBLK,(UNAPL(J,IBLK,IAPPL),J=1,6),
           1                 (UNAPL(J,IBLK,IAPPL),J=11,14),
           2                 UNAPL(20,IBLK,IAPPL),  IBLK=1,5)
      C
      C                              CONVERT APPLICATIONS FROM METRIC TO ENGLISH
      C
            IF (INPUT .EQ. ENGL)  GO TO 900
            DO 890  J=1,20
               DO 880  IBLK=1,5
                  SNAPL(J,IBLK,IAPPL) = SNAPL(J,IBLK,IAPPL)*.8924
```

```
                 UNAPL(J,IBLK,IAPPL) = UNAPL(J,IBLK,IAPPL)*.8924
      880          CONTINUE
      890       CONTINUE
      C
      900   CONTINUE
      C
      C
      910   RETURN
      C
      C
      C
      3000  FORMAT  (A4)
      3001  FORMAT  (A8)
      3010  FORMAT  (6F8.0)
      3020  FORMAT  (A4,9X,I3)
      4000  FORMAT ('0',/,'C','NUTRIENTS - ',A5,11X,'ORG-N',3X,'NH3-S',3X,
           1         'NH3-A',3X,'NO3+NO2',4X,'N2',2X,'PLNT-N',3X,'ORG-P',
           2         3X,'PO4-S',3X,'PO4-A',2X,'PLNT-P',6X,'CL')
      4005  FORMAT  ('0')
      4010  FORMAT ('C',3X,'SURFACE LAYER')
      4020  FORMAT ('C',6X,'STORAGE',12X,F8.0,5F8.3,F8.0,3F8.3,F8.3)
      4025  FORMAT ('C',6X,'AVERAGE',12X,F8.0,5F8.3,F8.0,3F8.3,F8.3)
      4030  FORMAT (' ',12X,'BLOCK',I2,6X,F8.0,5F8.3,F8.0,3F8.3,F8.3)
      4090  FORMAT ('0',3X,'UPPER ZONE')
      4110  FORMAT ('C',3X,'LOWER ZONE')
      4120  FORMAT ('0',3X,'GROUNDWATER')
      4599  FORMAT  ('0','---ERROR---  EXPECTING THE WORD  NUTRIENT  BUT ',
           1          'READ IN ',A8)
      4600  FORMAT  ('1',40X,'NUTRIENT SIMULATION INFORMATION')
      4610  FORMAT  ('0',3X,'TIME STEP FOR TRANSFORMATIONS = ',I5,' MIN',
           1          /,' ',3X,'NUMBER OF NUTRIENT APPLICATIONS = ',I2,
           2          /,' ',3X,'DATE OF PLANT HARVESTING = ',I4,
           3          /,' ',3X,'FRACTION OF MAXIMUM MONTHLY UPTAKE ',
           4           /,' ',6X,'UPPER LAYERS = ',12F6.3,
           5           /,' ',6X,'LOWER ZONE =    ',12F6.3)
      4619  FORMAT  ('0','---ERROR---  IN REACTION RATES SECTION OF INPUT')
      4620  FORMAT  ('0','---ERROR--- IN ',A4,' REACTION RATES SECTION OF ',
           1          'INPUT')
      4630  FORMAT  (' ',12X,'EXPECTING ',A5,' BUT READ IN  ',A4)
      4640  FORMAT  (' ',12X,'EXPECTING NITR, PHOS, OR END, BUT READ ',
           1          'IN  ',A4)
      4650  FORMAT  ('0','NITROGEN REACTION RATES',8(5X,A4)/,
           1          ' ',6X,'SURFACE',12X,8(2X,F7.4)/
           2          ' ',6X,'UPPER ZONE',9X,8(2X,F7.4)/
           3          ' ',6X,'LOWER ZONE',9X,8(2X,F7.4)/
           4          ' ',6X,'GROUNDWATER',8X,8(2X,F7.4)/
           5          ' ',3X,'TEMPERATURE COEF.',4X,8F9.3)
      4660  FORMAT  ('0','PHOSPHORUS REACTION RATES',  5(5X,A4)/
           1          ' ',6X,'SURFACE',12X,5(2X,F7.4)  /
           2          ' ',6X,'UPPER ZONE',9X,5(2X,F7.4)  /
           3          ' ',6X,'LOWER ZONE',9X,5(2X,F7.4)  /
           4          ' ',6X,'GROUNDWATER',8X,5(2X,F7.4)  /
           5          ' ',3X,'TEMPERATURE COEF.',4X,5F9.3)
      4665  FORMAT  ('0','---ERROR---  EXPECTING  INIT  BUT READ IN ',A4)
      4670  FORMAT  ('0','---ERROR--- IN INITIAL ',A5,' STORAGE SECTION OF ',
           1          'INPUT')
      4690  FORMAT  (' ',11X,'FOR ',A5,' EXPECTING BLOCKS=0, 1, OR 5',
           1          ' INPUT VALUE = ',I3)
      4700  FORMAT  (' ',3X,'INITIAL STORAGES')
      4710  FORMAT  ('0','---ERROR--- NUMBER OF NUTRIENT APPLICATIONS CAN ',
           1          'RANGE FROM 0 TO 5 ONLY, INPUT VALUE = ',I3)
      4720  FORMAT  ('0','---ERROR--- IN NUTRIENT APPLICATION SECTION')
      4725  FORMAT  ('0','---ERROR--- IN INITIAL STORAGE SECTION')
      4730  FORMAT  (' ',11X,'IN APPLICATION NO. ',I2,' THE DAY OF ',
           1          'APPLICATION IS NOT IN THE RANGE 1 TO 366, INPUT ',
           2          'VALUE = ',I3)
```

```
 4735 FORMAT  (' ',12X,'THE DAY OF APPLICATION NO. ',I2,
     1         ' DOES NOT EXCEED THE PREVIOUS APPLICATION DAY')
 4740 FORMAT  ('0',11X,'EXPECTING NITR, PHOS, CHLO, OR END, BUT ',
     1         'READ IN ',A5)
 4745 FORMAT  ('0',11X,'EXPECTING NITR, PHOS, CHLO, OR END, BUT ',
     1         'READ IN ',A5,' FOR APPL. NO. ',I2)
 4750 FORMAT  ('0',11X,'IN APPLICATION NO. ',I2,' FOR ',A4,
     1         'EXPECTING ',A5, ' BUT READ IN ',A5)
 4760 FORMAT  ('0','APPLICATION FOR DAY ',I3)
 4770 FORMAT  ('0','INVALID TSTEP SPECIFIED, INPUT WAS ',I4,
     1         ' EXECUTION CONTINUING WITH TSTEP = 60 MIN.')
 4780 FORMAT  ('0','---ERROR---  INVALID NITROGEN REACTION RATE FOR ',
     1         A4,' IN ZONE ',I2,' INPUT VALUE = ',F8.6)
 4790 FORMAT  ('0','---WARNING---  NITROGEN REACTION RATE ',A4,
     1         ' IN ZONE ',I2,/14X,
     2         ' IS TOO LARGE FOR TIME STEP SELECTED, CONSIDER ',
     3         'REDUCING TSTEP FOR MORE ACCURATE SOLUTION')
 4800 FORMAT  ('0','---ERROR---  INVALID PHOSPHORUS REACTION RATE FOR ',
     1         A4,' IN ZONE ',I2,' INPUT VALUE = ',F8.6)
 4810 FORMAT  ('0','---WARNING---  PHOSHORUS REACTION RATE ',A4,
     1         ' IN ZONE ',I2/14X,
     2         ' IS TOO LARGE FOR TIME STEP SELECTED, CONSIDER ',
     3         'REDUCING TSTEP FOR MORE ACCURATE SOLUTION')
 4812 FORMAT  ('0','---WARNING---  TEMPERATURE COEFFICIENT FOR NITROGEN'
     1         ,' REACTION RATE ',A4,' SHOULD BE >= 1.0')
 4814 FORMAT  ('0','---WARNING---  TEMPERATURE COEFFICIENT FOR ',
     1         'PHOSPHORUS REACTION RATE ',A4,' SHOULD BE >= 1.0')
 4820 FORMAT  ('0',3X,'TOTAL NITROGEN IN SYSTEM = ',2X,F10.3,2X,A5/
     1         ' ',3X,'TOTAL PHOSPHORUS IN SYSTEM = ',F10.3,2X,A5/
     2         ' ',3X,'TOTAL CHLORIDE IN SYSTEM = ',2X,F10.3,2X,A5)
 5000 FORMAT (8X,I4,8X,I4,8X,I4)
 5001 FORMAT (8X,12F6.0)
C
C
      END
C
C
C
C
      SUBROUTINE NUTRNT(UZSN,UZF,LZSN,LZF)
C
C                             THIS SUBROUTINE IS CALLED EVERY INTERVAL ON
C                             A RAIN DAY OR ONLY ONCE A DAY ON A NO RAIN
C                             DAY TO COMPUTE NUTRIENT LOSSES AND TRANS-
C                             FORMATIONS.  ADVECTIVE LOSS IS COMPUTED
C                             EVERYTIME SUBROUTINE IS CALLED, WHILE
C                             CHEMICAL AND BIOLOGICAL TRANSFORMATIONS
C                             ARE DONE AT SELECTED INTERVALS AS
C                             SPECIFIED BY INPUT PARAMETER TSTEP.
C
C                             DECLARATIONS
C                             COMMON VARIABLES
C
      REAL UZSN,UZF,LZSN,LZF
      INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      REAL  DELT,
     1          SNT(20),SNRSM(20,5),SNROM(20,5),
     2          UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
     3          NRSM(20,5),LNRPM(20),
     4          SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
     5          SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
     6          LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
     7          TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
     8          KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
      DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1            STEMP(24),UTEMP(24)
```

```
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,UN,UNT,UNI,UNIT,
     1              UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2              SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3              TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4              KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5              TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
C
      INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
      REAL  RU,HYMIN,DPST,LZS,AREA,RESB1(5),ROSB(5),SRGX(5),INTF(5),
     1        RGX(5),INFL(5),UZSB(5),APERCB(5),RIB(5),ERSN(5),RESB(5),
     2        M,P3,A,LTEMP,LMOIST,MUZ,MLZ
C
      COMMON /ALL/  RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1              RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,
     2              M,P3,A,CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,
     3              IMIN,IHR,TF,JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,
     4              ON,OFF,SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
C                         DECLARATIONS FOR INTERNAL STORAGE ALLOCATION
C
      REAL  SNRS(20,5),SNRO(20,5),SNRP(20,5),ASNRS(20,5),
     1        ASNRST(20),ASNRO(20,5),  ASNROT(20),
     2        ASNRP(20,5),ASNRPT(20),UNTI(20,5),UNRI(20,5),
     3        UNRP(20,5),NRS(20,5),AUNRI(20,5),AUNRIT(20),
     4        AUNRP(20,5),AUNRPT(20),ANRS(20,5),
     6        ANRST(20),LNRP(20),ALNRP(20),
     7        ASNRB(20,5),ASNRBT(20),AUNRB(20,5),
     8        AUNRBT(20),ALNRB(20),AGNRB(20),ATNRB(20)
C
C                         DECLARATIONS FOR OTHER INTERNAL VARIABLES
C
      INTEGER ITIME,NCYCLE,IHOUR,IBIO,IZONE,IBLK
C
      DOUBLE PRECISION  CONC,LBPAC,KGPHA,FAR,CEL,DEG
C
      REAL  FS,FO,FP,TW,TWI,FII,FLI,T(4),FT,
     1        DELNB(20,5),DELN(20),
     2        SUM,SUMD,SUMA,NDSM(20),NDSC(20),NASM(20),NASC(20),
     3        ERSNT,CONFC,CONFS,TOTN,TOTP,TOTNC,TOTPC,SEDC,
     4        CONVF,SNMET(20,5),UNMET(20,5),LNMET(20),GNMET(20),
     5        SNTMET(20),UNTMET(20),UNITMT(20),UNIMET(20,5),
     6        PA,DUMV(20),DUMA(20,5),INFW(5),JNFW(5),KNFW
      REAL    STEMPF(24),UTEMPF(24),LTEMPF
C
C                         INITIALIZATION AND DECLARATION OF SELECTORS
C                         USED FOR ADVECTING AND REMOVING NUTRIENTS
C                         BY MEANS OF SEDIMENT (SD), OVERLAND FLOW
C                         (OF), INTERFLOW (IF), PERCOLATION (PC),
C                         BIOLOGICAL (BL).
C
      INTEGER  SELSD(20),SELOF(20),SELIF(20),SELPC(20),SELBL(20)
      DATA ASNRS/100*0.0/, ASNRO/100*0.0/, ASNRP/100*0.0/,
     1     AUNRI/100*0.0/, AUNRP/100*0.0/, ANRS /100*0.0/,
     2     ALNRP/ 20*0.0/, ASNRB/100*0.0/, AUNRB/100*0.0/,
     3     ALNRB/ 20*0.0/, AGNRB/ 20*0.0/, ATNRB/ 20*0.0/
      DATA LBPAC/'LB/AC'/,KGPHA/'KG/HA'/,FAR/'F'/,CEL/'C'/
      DATA DELNB/100*0.0/, D[illegible]*0.0/, CONVF/1.121/
      DATA SELSD/1,0,1,0,0,0,0,0,[illegible],0,1,0,1,0,0,0,0,0,0,0/,
     1     SELOF/0,1,0,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,1/,
     2     SELIF/0,1,0,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,1/,
     3     SELPC/0,1,0,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,1/,
     4     SELBL/0,0,0,0,1,1,0,0,0,0,0,0,0,1,0,0,0,0,0,0/
C
```

```
C
C                         BRIEF DESCRIPTION OF VARIABLE NAMING CONVENTION:
C                         1) FIRST TWO LETTERS SN,UN,LN,GN STAND FOR SURFACE,
C                            UPPER ZONE, LOWER ZONE, AND GROUNDWATER NUTRIENTS
C                            UNI = INTERFLOW STORAGE OF DISSOLVED NUTRIENTS
C                         2) FIRST LETTER A STANDS FOR AN ACCUMULATION OF A
C                            NUTRIENT LOSS OVER THE INTERVALS BETWEEN PRINTING
C                         3) THE THIRD OR FOURTH LETTER 'R' STANDS FOR REMOVAL
C                         4) FOLLOWING THE 'R' A LETTER INDICATES THE CAUSE OF
C                            REMOVAL:  'S'=SEDIMENT, 'O'=OVERLAND FLOW,
C                            'P'=PERCOLATION, 'I'=INTERFLOW, 'B'=BIOLOGICAL
C                         5) LETTERS 'M' AND 'Y' INDICATE MONTHLY AND YEARLY
C                            SUMS OF REMOVALS. MONTHLY SUM IS ACCUMULATED IN
C                            NUTRNT AND PASSED TO MAIN FOR OUTPUT, AND YEARLY
C                            AMOUNTS ARE CALCULATED AND PRINTED IN MAIN
C                         6) THE LETTER 'T' APPEARING AT THE VERY END INDICATES
C                            THE TOTAL OR AVERAGE MASS OF THE 5 BLOCKS IN THE
C                            SURFACE AND UPPER ZONES
C
C                            NUTRIENTS ARE STORED IN VECTORS AND ARRAYS IN THE
C                            FOLLOWING SEQUENCE OF ELEMENTS:
C                            1 = ORG-N,  ORGANIC NITROGEN
C                            2 = NH4-S,  AMMONIUM IN SOLUTION
C                            3 = NH4-A,  AMMONIUM ADSORBED TO SOIL
C                            4 = NO3+NO2,   NITRITE PLUS NITRATE
C                            5 = N2-GAS, NITROGEN GAS FROM DENITRIFICATION
C                            6 = PLNT-N, PLANT NITROGEN
C                            7 = OPEN
C                            8 = OPEN
C                            9 = OPEN
C                            10 = OPEN
C                            11 = ORG-P,  ORGANIC PHOSPHORUS
C                            12 = PO4-S,  PHOSPHATE IN SOLUTION
C                            13 = PO4-A,  PHOSPHATE ADSORBED TO SOIL
C                            14 = PLNT-P, PLANT PHOSPHORUS
C                            15 = OPEN
C                            16 = OPEN
C                            17 = OPEN
C                            18 = OPEN
C                            19 = OPEN
C                            20 = CL,      CHLORIDE
C
      PA = 1.0 - A
C
C                                  ADVECTIVE LOSSES
C
C                                  SURFACE ZONE
C
      DO 120  IBLK=1,5
C
C                                  SEDIMENT REMOVAL
C
         IF (ERSN(IBLK) .LE. 0.0)  GO TO 40
         FS = 2000.*AREA*0.2*ERSN(IBLK)/M
         IF (FS .GT. 1.0)  FS=1.0
         DO 20  J=1,20
            SNRS(J,IBLK) = SELSD(J)*FS*SN(J,IBLK)
   20    CONTINUE
         GO TO 60
   40    DO 50  J=1,20
            SNRS(J,IBLK) = 0.0
   50    CONTINUE
C
C                                  OVERLAND FLOW AND PERCOLATION
C
C  45302.4 = 0.2 * 43560 FT(2)/ACRE * 1 FT/12 INCHES * 62.4 LB/FT(3)
C
   60    IF ((P3+RESB1(IBLK)) .LE. 0.0)  GO TO 80
```

```
         FT = PA*(P3+RESB1(IBLK))
         INFW(IBLK) = AREA*FT*45302.4
         FO = RESB(IBLK)/FT
         FP = RIB(IBLK)/(P3+RESB1(IBLK))
         DO 70  J=1,20
            SNRO(J,IBLK) = SELOF(J)*FO*SN(J,IBLK)
            SNRP(J,IBLK) = SELPC(J)*FP*SN(J,IBLK)
70       CONTINUE
         GO TO 100
80       DO 90  J=1,20
            SNRO(J,IBLK) = 0.0
            SNRP(J,IBLK) = 0.0
90       CONTINUE
         INFW(IBLK) = 0.0
C
C                          CHANGE SURFACE STORAGES AND ACCUMULATE
C                          REMOVALS
C
100      DO 110  J=1,20
            SN(J,IBLK) = SN(J,IBLK) - SNRS(J,IBLK) - SNRO(J,IBLK) -
     1                 SNRP(J,IBLK)
            UN(J,IBLK) = UN(J,IBLK) + SNRP(J,IBLK)
            ASNRS(J,IBLK) = ASNRS(J,IBLK) + SNRS(J,IBLK)
            ASNRO(J,IBLK) = ASNRO(J,IBLK) + SNRO(J,IBLK)
            ASNRP(J,IBLK) = ASNRP(J,IBLK) + SNRP(J,IBLK)
110      CONTINUE
120   CONTINUE
C
C                          UPPER ZONE
C
      DO 220  IBLK=1,5
C
C                          PERCOLATION AND INTERFLOW
C                          UNTI = TRANSFER FROM UZ TO INTERFLOW
C
C  UZFM REDUCES SOLUTE PERCOLATION FOR SOIL MOISTURE LESS THAN UZF*UZSN
C
         TW = UZSB(IBLK) + RGX(IBLK) + APERCB(IBLK) + INFL(IBLK)
         UNFW(IBLK) = AREA*PA*TW*45302.4
         TWI = SRGX(IBLK) + INTF(IBLK)
         IF (TW .LE. 0.0)  GO TO 140
         FII = RGX(IBLK)/TW
         UZFM = UZSB(IBLK)/(UZSN*UZF)
         IF (UZFM.GE.1.0) UZFM = 1.0
         FP = UZFM*(INFL(IBLK) + APERCB(IBLK))/TW
         DO 130  J=1,20
            UNTI(J,IBLK) = SELIF(J)*FII*UN(J,IBLK)
            UNI(J,IBLK) = UNI(J,IBLK) + UNTI(J,IBLK)
            UNRP(J,IBLK) = SELPC(J)*FP*UN(J,IBLK)
            IF (TF.EQ.1.OR.UNI(J,IBLK).LE.0.0) GO TO 130
            UN(J,IBLK) = UN(J,IBLK) + UNI(J,IBLK)
            UNI(J,IBLK) = 0.0
130      CONTINUE
         GO TO 160
140      DO 150  J=1,20
            UNTI(J,IBLK) = 0.0
            UNRP(J,IBLK) = 0.0
            IF (TF.EQ.1.OR.UNI(J,IBLK).LE.0.0) GO TO 150
            UN(J,IBLK) = UN(J,IBLK) + UNI(J,IBLK)
            UNI(J,IBLK) = 0.0
150      CONTINUE
C
C                          LOSS FROM INTERFLOW STORAGE
C
160      IF (TWI .LE. 0.0)  GO TO 180
         FLI = INTF(IBLK)/TWI
         DO 170  J=1,20
```

```
                 UNRI(J,IBLK) = FLI*UNI(J,IBLK)
170         CONTINUE
            GO TO 200
180         DO 190  J=1,20
               UNRI(J,IBLK) = 0.0
190         CONTINUE
C
C                         REMOVE AND ADD STORAGES AND ACCUMULATE
C
200         DO 210  J=1,20
               UN(J,IBLK) = UN(J,IBLK) - UNTI(J,IBLK) - UNRP(J,IBLK)
               UNI(J,IBLK) = UNI(J,IBLK) - UNRI(J,IBLK)
               AUNRI(J,IBLK) = AUNRI(J,IBLK) + UNRI(J,IBLK)
               AUNRP(J,IBLK) = AUNRP(J,IBLK) + UNRP(J,IBLK)
               LN(J) = LN(J) + UNRP(J,IBLK)*0.2
210         CONTINUE
220      CONTINUE
C
C                         COMPUTE NUTRIENT REMOVAL TO STREAM (NRS)
C                         AND ACCUMULATIONS
C
         DO 240  IBLK=1,5
            DO 230  J=1,20
               NRS(J,IBLK) = SNRS(J,IBLK) + SNRO(J,IBLK) + UNRI(J,IBLK)
               ANRS(J,IBLK) = ANRS(J,IBLK) + NRS(J,IBLK)
230         CONTINUE
240      CONTINUE
C
C                         LOWER ZONE
C
C  226512 = 43560 FT(2)/ACRE * 1 FT/12 INCHES * 62.4 LB/FT(3)
C
C
C  LZFM REDUCES SOLUTE PERCOLATION FOR SOIL MOISTURE LESS THAN LZF*LZSN
         TW = LZS + DPST
         KNFW = AREA*TW*226512.0
         IF (TW .LE. 0.0)  GO TO 260
         LZFM = LZS/(LZSN*LZF)
         IF (LZFM.GE.1.0) LZFM =1.0
         FP = LZFM*DPST/TW
         DO 250  J=1,20
            LNRP(J) = SELPC(J)*FP*LN(J)
250      CONTINUE
         GO TO 280
260      DO 270  J=1,20
            LNRP(J) = 0.0
270      CONTINUE
C
280      DO 290  J=1,20
            LN(J) = LN(J) - LNRP(J)
            GN(J) = GN(J) + LNRP(J)
            ALNRP(J) = ALNRP(J) + LNRP(J)
290      CONTINUE
C
C                         GROUNDWATER
C                         NO ADVECTIVE LOSS FROM GROUNDWATER
C
C
C                         CHECK TO SEE IF PHYSICAL AND BIOLOGICAL
C                         TRANSFORMATIONS ARE TO BE DONE THIS
C                         INTERVAL ON A RAIN DAY, OR SETUP THE
C                         NUMBER OF TIMES TO LOOP FOR A NO RAIN
C                         DAY
C
         IF (TF .GT. 1)  GO TO 300
         ITIME = IMIN + 60*IHR
         IF ( MOD(ITIME,TSTEP) .NE. 0)  GO TO 810
         NCYCLE = 1
```

```
            GO TO 310
  300       NCYCLE = NSTEP
C
  310       DO 800  IBIO=1,NCYCLE
C
C                                  COMPUTE HOUR OF THE DAY TO ACCESS HOURLY
C                                  SOIL TEMP DATA FOR THE 4 SOIL ZONES:
C                                  SURFACE, UPPER, LOWER, GROUNDWATER
C
               IF (TF .GT. 1)  GO TO 320
               IHOUR = IHR + 1
               GO TO 330
  320          IHOUR = 1 + (IBIO*TSTEP)/60
  330          IF (IHOUR .EQ. 25)  IHOUR=24
               T(1) = STEMP(IHOUR)
               T(2) = UTEMP(IHOUR)
               T(3) = LTEMP
               T(4) = LTEMP
C
C                     TRANSFORMATIONS BYPASSED AT TEMPERATURES BELOW 4 DEG. C
C
C                                  SURFACE ZONE TRANSFORMATIONS
C
               IF (SFLG .EQ. 0)  GO TO 450
               IZONE = 1
               IF (T(1) .LE. 4.0) GO TO 450
C
              CALL TRANS (DELT,IZONE,DUMV,SN,KN,THKN,KP,THKP,T,DUMV,DELNB,
     1                            AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
C
C                                 COMPUTE AND ACCUMULATE AMOUNT REMOVED
C                                 BIOLOGICALLY
C
              DO 440  IBLK=1,5
                 DO 430  J=1,20
                    ASNRB(J,IBLK) = ASNRB(J,IBLK) + SELBL(J)*DELNB(J,IBLK)
  430            CONTINUE
  440         CONTINUE
C
C                                 UPPER ZONE TRANSFORMATIONS
C
  450         IF (UFLG .EQ. 0)  GO TO 560
              IZONE = 2
              IF (T(2) .LE. 4.0) GO TO 560
C
              CALL TRANS (DELT,IZONE,DUMV,UN,KN,THKN,KP,THKP,T,DUMV,DELNB,
     1                            AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
C
C
              DO 550  IBLK=1,5
                 DO 540  J=1,20
                    AUNRB(J,IBLK) = AUNRB(J,IBLK) + SELBL(J)*DELNB(J,IBLK)
  540            CONTINUE
  550         CONTINUE
C
C                                 LOWER ZONE TRANSFORMATIONS
C
  560         IF (LFLG .EQ. 0)  GO TO 660
              IZONE = 3
              IF (T(3) .LE. 4.0) GO TO 660
              IF (KNFW.LE.0.000001) GO TO 660
C
              CALL TRANS (DELT,IZONE,LN,DUMA,KN,THKN,KP,THKP,T,DELN,DUMA,
     1                            AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
C
              DO 650  J=1,20
                 ALNRB(J) = ALNRB(J) + SELBL(J)*DELN(J)
  650      CONTINUE
C
C                              GROUNDWATER ZONE
C
  660      IF (GWFLG .EQ. 0)  GO TO 800
           IZONE = 4
           IF (T(4) .LE. 4.0) GO TO 800
C
           CALL TRANS (DELT,IZONE,GN,DUMA,KN,THKN,KP,THKP,T,DELN,DUMA,
     1                         AREA,M,AUZ,HLZ,INFW,JNFW,KNFW)
C
           DO 750  J=1,20
              AGNRB(J) = AGNRB(J) + SELBL(J)*DELN(J)
  750      CONTINUE
C
  800   CONTINUE
C
C                              END OF NO RAIN INTERVAL LOOP
C
  810 IF (PRNTKE .EQ. 0)  GO TO 1300
C
C                              COMPUTE BIOLOGICAL REMOVALS
C                              ACCUMULATE MONTHLY VALUES OF ADVECTIVE
C                              AND BIOLOGICAL REMOVALS
C                              ATNRB = ACCUM. TOTAL NUTR REMOVAL BIOL.
C
        DO 920  J=1,20
           SUM = 0.0
           DO 910  IBLK=1,5
              SUM = SUM + ASNRB(J,IBLK) + AUNRB(J,IBLK)
  910      CONTINUE
           ATNRB(J) = SUM/5. + ALNRB(J) + AGNRB(J)
  920   CONTINUE
C
        DO 940  J=1,20
           DO 930  IBLK=1,5
              SNRSM(J,IBLK) = SNRSM(J,IBLK) + ASNRS(J,IBLK)
              SNROM(J,IBLK) = SNROM(J,IBLK) + ASNRO(J,IBLK)
              UNRIM(J,IBLK) = UNRIM(J,IBLK) + AUNRI(J,IBLK)
              NRSM(J,IBLK) = NRSM(J,IBLK) + ANRS(J,IBLK)
              SNRBM(J,IBLK) = SNRBM(J,IBLK) + ASNRB(J,IBLK)
              UNRBM(J,IBLK) = UNRBM(J,IBLK) + AUNRB(J,IBLK)
  930      CONTINUE
           LNRPM(J) = LNRPM(J) + ALNRP(J)
           LNRBM(J) = LNRBM(J) + ALNRB(J)
           GNRBM(J) = GNRBM(J) + AGNRB(J)
           TNRBM(J) = TNRBM(J) + ATNRB(J)
  940   CONTINUE
C
        IF (PRNTKE .EQ. 2)  GO TO 1200
C                              OUTPUT OPTIONS
C
        IF (HYCAL .EQ. PROD)  GO TO 1100
        IF (TF.GT.1 .OR. RU.LT.HYMIN)  GO TO 1200
C
C                              COMPUTE CONCENTRATIONS AND MASSES IN STREAM
C                              FOR CALIBRATION OUTPUT
C                              NDSM=NUTRIENTS DISSOLVED IN STREAM,MASS
C                              NDSC=NUTRIENTS DISSOLVED IN STREAM, CONC.
C                              NASM=NUTRIENTS ADSORBED IN STREAM, MASS
C                              NASC=NUTRIENTS ADSORBED IN STREAM, CONC.
C                              CONFC = CONVERSION FACTOR TO GET MG/L UNITS
C                              CONFS = CONV. FACTOR TO GET ADSORBED NUTR.
C                                      CONC. IN PPM OF SEDIMENT
C
        ERSNT = 0.0
        DO 945  IBLK=1,5
           ERSNT = ERSNT + ERSN(IBLK)
  945 CONTINUE
      ERSNT = ERSNT/5.
      CONFC = 454000./(RU*TIMFAC*60.*28.32)
      IF (ERSNT .GT. 0.0)  CONFS = 1.0E6/(ERSNT*2000.*AREA)
      DO 970  J=1,20
         SUMD = 0.0
         SUMA = 0.0
         DO 950  IBLK=1,5
            SUMD = SUMD + ASNRO(J,IBLK) + AUNRI(J,IBLK)
            SUMA = SUMA + ASNRS(J,IBLK)
  950    CONTINUE
         NDSM(J) = SUMD*AREA/5.
         NDSC(J) = NDSM(J)*CONFC
         NASM(J) = SUMA*AREA/5.
         IF (ERSNT .LE. 0.0)  GO TO 960
            NASC(J) = NASM(J)*CONFS
         GO TO 970
  960    NASC(J) = 0.0
  970 CONTINUE
C
C                        COMPUTE TOTAL MASS OF N (TOTN) AND P (TOTP),CONC.
C                        OF TOTAL N (TOTNC) ,P (TOTPC), AND SEDIMENT(SEDC)
C                        PER WATER PHASE IN STREAM
C
      TOTN = 0.0
      TOTP = 0.0
      DO 971  J=1,6
         TOTN = TOTN +NDSM(J) + NASM(J)
  971 CONTINUE
      DO 972  J=11,14
         TOTP = TOTP + NDSM(J) + NASM(J)
  972 CONTINUE
C
      TOTNC = TOTN*CONFC
      TOTPC = TOTP*CONFC
      SEDC = (CONFC/CONFS)*1.0E3
C
C
C                              MODIFICATIONS FOR METRIC OUTPUT
C                              CONVERT MASS FROM LB. TO KG. CONC. IN MG/L
C
      IF (OUTPUT.EQ.ENGL .OR. OUTPUT.EQ.BOTH)  GO TO 1000
      DO 980  J=1,20
         NDSM(J) = NDSM(J)/2.205
         NASM(J) = NASM(J)/2.205
  980 CONTINUE
      TOTN = TOTN/2.205
      TOTP = TOTP/2.205
C
 1000 WRITE (6,4130)  NDSM(4),NDSM(2),NDSM(12),NDSM(20),
     1                NASM(3),NASM(1),NASM(13),NASM(11),TOTN,TOTP
      WRITE (6,4135)  SEDC
      WRITE (6,4140)  NDSC(4),NDSC(2),NDSC(12),NDSC(20),
     1                NASC(3),NASC(1),NASC(13),NASC(11),TOTNC,TOTPC
      GO TO 1200
C
C                              PRODUCTION OUTPUT
C                              COMPUTE WATERSHED AVG. FROM BLOCK STORAGES
C
 1100 DO 1120  J=1,20
         SNT(J) = 0.0
         UNT(J) = 0.0
         UNIT(J) = 0.0
         ASNRST(J) = 0.0
         ASNROT(J) = 0.0
         ASNRPT(J) = 0.0
         AUNRIT(J) = 0.0
         AUNRPT(J) = 0.0
```

```
            ANRST(J) = 0.0
            ASNRBT(J) = 0.0
            AUNRBT(J) = 0.0
            DO 1110  IBLK=1,5
               SNT(J) = SNT(J) + SN(J,IBLK)*0.2
               UNT(J) = UNT(J) + UN(J,IBLK)*0.2
               UNIT(J) = UNIT(J) + UNI(J,IBLK)*0.2
               ASNRST(J) = ASNRST(J) + ASNRS(J,IBLK)*0.2
               ASNROT(J) = ASNROT(J) + ASNRO(J,IBLK)*0.2
               ASNRPT(J) = ASNRPT(J) + ASNRP(J,IBLK)*0.2
               AUNRIT(J) = AUNRIT(J) + AUNRI(J,IBLK)*0.2
               AUNRPT(J) = AUNRPT(J) + AUNRP(J,IBLK)*0.2
               ANRST(J) = ANRST(J) + ANRS(J,IBLK)*0.2
               ASNRBT(J) = ASNRBT(J) + ASNRB(J,IBLK)*0.2
               AUNRBT(J) = AUNRBT(J) + AUNRB(J,IBLK)*0.2
 1110       CONTINUE
 1120  CONTINUE
 C
       IF (OUTPUT .EQ. METR)  GO TO 1130
       CONC = LBPAC
       WRITE (6,4005)
       WRITE (6,4060)  CONC
 C
 C                             SURFACE
 C
       WRITE (6,4010)
       WRITE (6,4020)  (SNT(J),J=1,6),(SNT(J),J=11,14),SNT(20)
       WRITE (6,4030)  (IBLK,(SN(J,IBLK),J=1,6),(SN(J,IBLK),J=11,14),
      1                SN(20,IBLK),  IBLK=1,5)
       WRITE (6,4040)
       WRITE (6,4050)  (ASNRST(J),J=1,6),(ASNRST(J),J=11,14),ASNRST(20)
       WRITE (6,4030) (IBLK,(ASNRS(J,IBLK),J=1,6),(ASNRS(J,IBLK),J=11,14)
      1               ,ASNRS(20,IBLK),  IBLK=1,5)
       WRITE (6,4060)  (ASNROT(J),J=1,6),(ASNROT(J),J=11,14),ASNROT(20)
       WRITE (6,4030) (IBLK,(ASNRO(J,IBLK),J=1,6),(ASNRO(J,IBLK),J=11,14)
      1               ,ASNRO(20,IBLK),  IBLK=1,5)
       WRITE (6,4070)  (ASNRPT(J),J=1,6),(ASNRPT(J),J=11,14),ASNRPT(20)
       WRITE (6,4030) (IBLK,(ASNRP(J,IBLK),J=1,6),(ASNRP(J,IBLK),J=11,14)
      1               ,ASNRP(20,IBLK),  IBLK=1,5)
       WRITE (6,4080)  (ASNRBT(J),J=1,6),(ASNRBT(J),J=11,14),ASNRBT(20)
       WRITE (6,4030) (IBLK,(ASNRB(J,IBLK),J=1,6),(ASNRB(J,IBLK),J=11,14)
      1               ,ASNRB(20,IBLK),  IBLK=1,5)
 C
 C                             UPPER ZONE
 C
       WRITE (6,4090)
       WRITE (6,4020)  (UNT(J),J=1,6),(UNT(J),J=11,14),UNT(20)
       WRITE (6,4030) (IBLK,(UN(J,IBLK),J=1,6),(UN(J,IBLK),J=11,14)
      1               ,UN(20,IBLK),  IBLK=1,5)
       WRITE (6,4100)  (UNIT(J),J=1,6),(UNIT(J),J=11,14),UNIT(20)
       WRITE (6,4030) (IBLK,(UNI(J,IBLK),J=1,6),(UNI(J,IBLK),J=11,14)
      1               ,UNI(20,IBLK),  IBLK=1,5)
       WRITE (6,4040)
       WRITE (6,4100)  (AUNRIT(J),J=1,6),(AUNRIT(J),J=11,14),AUNRIT(20)
       WRITE (6,4030) (IBLK,(AUNRI(J,IBLK),J=1,6),(AUNRI(J,IBLK),J=11,14)
      1               ,AUNRI(20,IBLK),  IBLK=1,5)
       WRITE (6,4070)  (AUNRPT(J),J=1,6),(AUNRPT(J),J=11,14),AUNRPT(20)
       WRITE (6,4030) (IBLK,(AUNRP(J,IBLK),J=1,6),(AUNRP(J,IBLK),J=11,14)
      1               ,AUNRP(20,IBLK),  IBLK=1,5)
       WRITE (6,4080)  (AUNRBT(J),J=1,6),(AUNRBT(J),J=11,14),AUNRBT(20)
       WRITE (6,4030) (IBLK,(AUNRB(J,IBLK),J=1,6),(AUNRB(J,IBLK),J=11,14)
      1               ,AUNRB(20,IBLK), IBLK=1,5)
 C
 C
 C                             TOTAL TO STREAM
 C
       WRITE (6,4015)  (ANRST(J),J=1,6),(ANRST(J),J=11,14),ANRST(20)
 C
```

```
C                                   LOWER ZONE AND GROUNDWATER
C
      WRITE (6,4110)
      WRITE (6,4020)  (LN(J),J=1,6),(LN(J),J=11,14),LN(20)
      WRITE (6,4040)
      WRITE (6,4070)  (ALNRP(J),J=1,6),(ALNRP(J),J=11,14),ALNRP(20)
      WRITE (6,4080)  (ALNRB(J),J=1,6),(ALNRB(J),J=11,14),ALNRB(20)
      WRITE (6,4120)
      WRITE (6,4020)  (GN(J),J=1,6),( N(J),J=11,14),GN(20)
      WRITE (6,4040)
      WRITE (6,4080)  (AGNRB(J),J=1,6),(AGNRB(J),J=11,14),AGNRB(20)
C
C            CONVERT DAILY SOIL TEMPERATURE TO ENGLISH UNITS
C
      DO 1125 I = 6,17,11
         STEMPF(I) = STEMP(I) * 9./5. + 32.05
         UTEMPF(I) = UTEMP(I) * 9./5. + 32.05
 1125 CONTINUE
      LTEMPF = LTEMP * 9./5. + 32.05
C
C                                   DAILY SOIL TEMPERATURE
C
      DEG = FAR
      WRITE (6,4124) DEG
      WRITE (6,4125) STEMPF(17), STEMPF(6)
      WRITE (6,4126) UTEMPF(17), UTEMP(6)
      WRITE (6,4127) LTEMPF
C
C
 1130 IF (OUTPUT .EQ. ENGL)  GO TO 1200
C
C                                   METRIC CONVERSIONS FOR OUTPUT
C
      CONC = KGPHA
      DO 1150  J=1,20
         SNTMET(J) = SNT(J)*CONVF
         ASNRST(J) = ASNRST(J)*CONVF
         ASNROT(J) = ASNROT(J)*CONVF
         ASNRPT(J) = ASNRPT(J)*CONVF
         ASNRBT(J) = ASNRBT(J)*CONVF
C
         UNTMET(J) = UNT(J)*CONVF
         UNITMT(J) = UNIT(J)*CONVF
         AUNRIT(J) = AUNRIT(J)*CONVF
         AUNRPT(J) = AUNRPT(J)*CONVF
         AUNRBT(J) = AUNRBT(J)*CONVF
C
         ANPST(J) = ANRST(J)*CONVF
         LNMET(J) = LN(J)*CONVF
         ALNRP(J) = ALNRP(J)*CONVF
         ALNRB(J) = ALNRB(J)*CONVF
         GNMET(J) = GN(J)*CONVF
         AGNRB(J) = AGNRB(J)*CONVF
         DO 1140  IBLK=1,5
            SNMET(J,IBLK) = SN(J,IBLK)*CONVF
            ASNRS(J,IBLK) = ASNRS(J,IBLK)*CONVF
            ASNRO(J,IBLK) = ASNRO(J,IBLK)*CONVF
            ASNRP(J,IBLK) = ASNRP(J,IBLK)*CONVF
            ASNRB(J,IBLK) = ASNRB(J,IBLK)*CONVF
            UNMET(J,IBLK) = UN(J,IBLK)*CONVF
            UNIMET(J,IBLK) = UNI(J,IBLK)*CONVF
            AUNRI(J,IBLK) = AUNRI(J,IBLK)*CONVF
            AUNRP(J,IBLK) = AUNRP(J,IBLK)*CONVF
            AUNRB(J,IBLK) = AUNRB(J,IBLK)*CONVF
 1140    CONTINUE
 1150 CONTINUE
      WRITE (6,4005)
      WRITE (6,4000)  CONC
```

```
C
C                               SURFACE
C
      WRITE (6,4010)
      WRITE (6,4020)  (SNTMET(J),J=1,6),(SNTMET(J),J=11,14),SNTMET(20)
      WRITE (6,4030) (IBLK,(SNMET(J,IBLK),J=1,6),
     1                (SNMET(J,IBLK),J=11,14),
     2                SNMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4040)
      WRITE (6,4050)  (ASNRST(J),J=1,6),(ASNRST(J),J=11,14),ASNRST(20)
      WRITE (6,4030) (IBLK,(ASNRS(J,IBLK),J=1,6),(ASNRS(J,IBLK),J=11,14)
     1               ,ASNRS(20,IBLK),  IBLK=1,5)
      WRITE (6,4060)  (ASNROT(J),J=1,6),(ASNROT(J),J=11,14),ASNROT(20)
      WRITE (6,4030) (IBLK,(ASNRO(J,IBLK),J=1,6),(ASNRO(J,IBLK),J=11,14)
     1               ,ASNRO(20,IBLK),  IBLK=1,5)
      WRITE (6,4070)  (ASNRPT(J),J=1,6),(ASNRPT(J),J=11,14),ASNRPT(20)
      WRITE (6,4030) (IBLK,(ASNRP(J,IBLK),J=1,6),(ASNRP(J,IBLK),J=11,14)
     1               ,ASNRP(20,IBLK),  IBLK=1,5)
      WRITE (6,4080)  (ASNRBT(J),J=1,6),(ASNRBT(J),J=11,14),ASNRBT(20)
      WRITE (6,4030) (IBLK,(ASNRB(J,IBLK),J=1,6),(ASNRB(J,IBLK),J=11,14)
     1               ,ASNRB(20,IBLK),  IBLK=1,5)
C
C                               UPPER ZONE
C
      WRITE (6,4090)
      WRITE (6,4020)  (UNTMET(J),J=1,6),(UNTMET(J),J=11,14),UNTMET(20)
      WRITE (6,4030) (IBLK,(UNMET(J,IBLK),J=1,6),
     1               (UNMET(J,IBLK),J=11,14),
     2               UNMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4100)  (UNITMT(J),J=1,6),(UNITMT(J),J=11,14),UNITMT(20)
      WRITE (6,4030)  (IBLK,(UNIMET(J,IBLK),J=1,6),
     1               (UNIMET(J,IBLK),J=11,14),
     2               UNIMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4040)
      WRITE (6,4100)  (AUNRIT(J),J=1,6),(AUNRIT(J),J=11,14),AUNRIT(20)
      WRITE (6,4030) (IBLK,(AUNRI(J,IBLK),J=1,6),(AUNRI(J,IBLK),J=11,14)
     1               ,AUNRI(20,IBLK),  IBLK=1,5)
      WRITE (6,4070)  (AUNRPT(J),J=1,6),(AUNRPT(J),J=11,14),AUNRPT(20)
      WRITE (6,4030) (IBLK,(AUNRP(J,IBLK),J=1,6),(AUNRP(J,IBLK),J=11,14)
     1               ,AUNRP(20,IBLK),  IBLK=1,5)
      WRITE (6,4080)  (AUNRBT(J),J=1,6),(AUNRBT(J),J=11,14),AUNRBT(20)
      WRITE (6,4030) (IBLK,(AUNRB(J,IBLK),J=1,6),(AUNRB(J,IBLK),J=11,14)
     1               ,AUNRB(20,IBLK), IBLK=1,5)
C
C
C                               TOTAL TO STREAM
C
      WRITE (6,4015)  (ANRST(J),J=1,6),(ANRST(J),J=11,14),ANRST(20)
C
C                               LOWER ZONE AND GROUNDWATER
C
      WRITE (6,4110)
      WRITE (6,4020)  (LNMET(J),J=1,6),(LNMET(J),J=11,14),LNMET(20)
      WRITE (6,4040)
      WRITE (6,4070)  (ALNRP(J),J=1,6),(ALNRP(J),J=11,14),ALNRP(20)
      WRITE (6,4080)  (ALNRB(J),J=1,6),(ALNRB(J),J=11,14),ALNRB(20)
      WRITE (6,4120)
      WRITE (6,4020)  (GNMET(J),J=1,6),(GNMET(J),J=11,14),GNMET(20)
      WRITE (6,4040)
      WRITE (6,4080)  (AGNRB(J),J=1,6),(AGNRB(J),J=11,14),AGNRB(20)
C
C                               DAILY SOIL TEMPERATURE
C
      DEG = CEL
      WRITE (6,4124) DEG
      WRITE (6,4125) STEMP(17), STEMP(6)
      WRITE (6,4126) UTEMP(17), UTEMP(6)
      WRITE (6,4127) LTEMP
```

```
C
C
C                          ZERO OUT ACCUMULATIONS AFTER PRINTING
C
1200  DO 1220  J=1,20
         DO 1210  IBLK=1,5
            ASNRS(J,IBLK) = 0.0
            ASNRO(J,IBLK) = 0.0
            ASNRP(J,IBLK) = 0.0
            ASNRB(J,IBLK) = 0.0
            AUNRI(J,IBLK) = 0.0
            AUNRP(J,IBLK) = 0.0
            AUNRB(J,IBLK) = 0.0
            ANRS(J,IBLK) = 0.0
1210     CONTINUE
         ALNPP(J) = 0.0
         ALNRB(J) = 0.0
         AGNRB(J) = 0.0
1220  CONTINUE
C
C
1300  RETURN
C
C
C
4000  FORMAT ('0','NUTRIENTS - ',A5,11X,'ORG-N',3X,'NH4-S',3X,'NH4-A',
     1        3X,'NO3+NO2',4X,'N2',2X,'PLNT-N',3X,'ORG-P',3X,
     2        'PO4-S',3X,'PO4-A',2X,'PLNT-P',6X,'CL')
4005  FORMAT ('0')
4010  FORMAT ('0',3X,'SURFACE LAYER')
4015  FORMAT ('0',9X,'TOTAL TO STREAM ',F8.2,5F8.3,F8.2,3F8.3,F8.3)
4020  FORMAT ('0',6X,'STORAGE',12X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4124  FORMAT ('0','DAILY SOIL TEMPERATURE IN DEGREE ',A1)
4125  FORMAT ('0','   SURFACE ZONE MAX(4PM)  MIN(6AM)',
     1       /,' ',14X,F5.1,5X,F5.1)
4126  FORMAT ('0','   UPPER ZONE    MAX(4PM)  MIN(6AM)',
     1       /,' ',14X,F5.1,5X,F5.1)
4127  FORMAT ('0','   LOWER ZONE DAILY AVERAGE',/,' ',12X,F5.1)
4030  FORMAT (' ',12X,'BLOCK',I2,6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4040  FORMAT ('0',6X,'REMOVAL')
4050  FORMAT ('0',9X,'SEDIMENT',8X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4060  FORMAT ('0',9X,'OVERLAND FLOW',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4070  FORMAT ('0',9X,'PERCOLATION',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4080  FORMAT ('0',9X,'BIOLOGICAL',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4090  FORMAT ('0',3X,'UPPER ZONE')
4100  FORMAT ('0',9X,'INTERFLOW',7X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4110  FORMAT ('0',3X,'LOWER ZONE')
4120  FORMAT ('0',3X,'GROUNDWATER')
4130  FORMAT ('+',40X,6F8.3,4X,2F8.3)
4135  FORMAT (' ',30X,F8.2)
4140  FORMAT ('+',40X,8F8.1,4X,2F8.1)
C
      END
C
C
C
C
      SUBROUTINE TRANS (DELT,IZONE,N,NB,KN,THKN,KP,THKP,T,DELN,DELNB,
     I                 AREA,M,MUZ,MLZ,INFW,JNFW,KNFW)
C
C                        THIS SUBROUTINE
C                        1) CORRECTS REACTION RATES FOR SOIL TEMP
C                           LESS THAN 35 DEG C.
C                           KNC = VECTOR OF NITROGEN REACTION RATES
C                              CORRECTED FOR EFFECTS OF ENVIR. FACTORS
C                           KPC = VECTOR OF PHOSPHORUS RATES, CORRECTED
C                        2) DEVELOPS COEFFICIENT ARRAY OF CORRECTED RATES
C
```

```
C                                 3) THEN SOLVES A SYSTEM OF FIRST
C                                    ORDER DIFFERENTIAL EQUATIONS FOR THE
C                                    CONSTITUTENT CONCENTRATIONS AT THE NEXT
C                                    TIME STEP.
C
C                                    CALLING VARIABLES ARE:
C                                    N(20) = VECTOR OF CONCENTRATIONS  (LB/AC)
C                                    DELT = TIME STEP (DELTA T)  (HR)
C                                    IZONE = SOIL LAYERS 1 TO 4
C                                    KN(8,4) = NITROGEN REACTION RATES AT 35 C
C                                    THKN(8) = TEMP. CORRECTION COFF FOR KN
C                                    KP(5,4) = PHOSPHORUS RATES AT 35 C
C                                    THKP(5) = TEMP. COEF. FOR KP
C                                    T(4) = SOIL TEMP AT 4 SOIL LAYERS, DEG C
C                                    DELN(20) = CHANGE IN CONCENTRATION THIS
C                                               TIME STEP (LB/AC)
C
C                                    NB(20,5) = ARRAY OF CONCENTRATIONS,BY
C                                               BLOCK (LB/AC)
C                                    DELNB(20,5) = CHANGE IN NB, BY BLOCK
C                                                  (LB/AC)
C
C                                    AREA = TOTAL WATERSHED AREA (ACRES)
C                                    M = MASS OF SOIL IN SURFACE LAYER PER BLOCK
C                                    MUZ = MASS OF SOIL IN UPPER ZONE PER BLOCK
C                                    MLZ = MASS OF SOIL IN LOWER ZONE PER BLOCK
C                                             ALL MASSES ARE IN LBS
C
C                                    INFW(5) = MASS OF WATER IN SURFACE ZONE
C                                                        PER BLOCK
C                                    JNFW(5) = MASS OF WATER IN UPPER ZONE
C                                                        PER BLOCK
C                                    KNFW = MASS OF WATER IN LOWER ZONE
C
C                                    SOLUTION TECHNIQUE CONSIDERED HERE IS A
C                                    SIMPLE EULER INTEGRATION SCHEME:
C                                      Y(T+1) = Y(T) + DELT*DY(T)/DT
C                                    WITH
C                                      DY(T)/DT = C*Y(T)
C                                    SUBROUTINE COMPUTES AND RETURNS
C                                       DELN = DELT * C * Y
C                                    AND Y(T+1)
C
          REAL  DELT,DELN(20),C(20,20),
         1        KN(8,4),THKN(8),KP(5,4),THKP(5),T(4),
         2        DELNB(20,5),SUM,RELT,FTN(8),FTP(5),
         3        KNC(8),KPC(5),AREA,M,MUZ,MLZ,INFW(5),JNFW(5),KNFW,
         4        WMMAB(5),WKMA,SMMA,SCT,SWCT,LBA,PPMS(20),PPMSW(20)
          DOUBLE PRECISION  NB(20,5),N(20)
C
          INTEGER  IROW,ICOL,IBLK,IZONE
          DATA C/400*0.0/
C
C               DELN AND DELNB ARE ZEROED
C
          DO 10  J=1,20
             DELN(J) = 0.0
            DO 20 K=1,5
               DELNB(J,K) = 0.0
   20       CONTINUE
   10     CONTINUE
C
          IF (IZONE.EQ.1 .OR. IZONE.EQ.2)  GO TO 310
C
C                                    TEMPERATURE CORRECTION OF REACTION RATES
C
          IF (T(IZONE) .GE. 35)  GO TO 37
          RELT = T(IZONE) - 35.
```

```
            DO 35  J=1,8
               FTN(J) = THAN(J)**RELT
35          CONTINUE
            DO 36  J=1,5
               FTP(J) = THAP(J)**RELT
36          CONTINUE
            GO TO 40
37          DO 38  J=1,8
               FTN(J) = 1.0
38          CONTINUE
            DO 39  J=1,5
               FTP(J) = 1.0
39          CONTINUE
C
40          DO 41  J=1,8
               KNC(J) = KN(J,IZONE)*FTN(J)
41          CONTINUE
            DO 42  J=1,5
               KPC(J) = KP(J,IZONE)*FTP(J)
42          CONTINUE
C
C                                      DEVELOP COEFFICIENT ARRAY
C
            C(1,1) = -KNC(4)
            C(1,2) = KNC(5)
            C(1,4) = KNC(6)
            C(2,1) = KNC(4)
            C(2,2) = -(KNC(7) + KNC(1) + KNC(5))
            C(2,3) = KNC(8)
            C(3,2) = KNC(7)
            C(3,3) = -KNC(8)
            C(4,2) = KNC(1)
            C(4,4) = -(KNC(2) + KNC(3) + KNC(6))
            C(5,4) = KNC(2)
            C(6,4) = KNC(3)
C
            C(11,11) = -KPC(1)
            C(11,12) = KPC(2)
            C(12,11) = KPC(1)
            C(12,12) = -(KPC(2) + KPC(4) + KPC(3))
            C(12,13) = KPC(5)
            C(13,12) = KPC(4)
            C(13,13) = -KPC(5)
            C(14,12) = KPC(3)
C
C                                          SOLUTION
C
            IF (IZONE.EQ.4) GO TO 95
C
C                                                      LOWER ZONE
C
C                     CALC BOTH MASS PER ACRE OF SOIL AND MASS PER ACRE SOIL
C                            WATER INCLUDING A CONVERSION FACTOR TO PPM
C
            SMMA = MLZ/(1000000.*AREA)
            WMMA = KNFW/(1000000.*AREA)
            DO 90 IROW = 1,20
              SUM = 0.0
              DO 85 ICOL = 1,20
                GO TO (70,80,70,80,85,85,85,85,85,85,70,80,70,85,85,85,85,85,
     1                                    85,85), ICOL
C
70              PPMS(ICOL) = N(ICOL)/SMMA
                SCT = C(IROW,ICOL)*PPMS(ICOL)
                LBA = SCT*SMMA
                SUM = SUM + LBA
                GO TO 85
C
```

```
80        PPMSW(ICOL) = N(ICOL)/WMMA
          SWCT = C(IROW,ICOL)*PPMSW(ICOL)
          LBA = SWCT*WMMA
          SUM = SUM + LBA
          GO TO 85
85      CONTINUE
          DELN(IROW) = DELT*SUM
90    CONTINUE
      DO 91   J=1,20
         N(J) = N(J) + DELN(J)
91    CONTINUE
      RETURN
C
C                GROUNDWATER
C
95    DO 200  IROW=1,20
         SUM = 0.0
         DO 100  ICOL=1,20
            SUM = SUM + C(IROW,ICOL)*N(ICOL)
100      CONTINUE
         DELN(IROW) = DELT*SUM
200   CONTINUE
      DO 300  J=1,20
         N(J) = N(J) + DELN(J)
300   CONTINUE
      RETURN
C
C                              FOLLOWING SECTION IS FOR THE BLOCKS
C                              USED IN THE SURFACE AND UPPER ZONE
C
C
C                              TEMPERATURE CORRECTION OF REACTION RATES
C
310   IF (T(IZONE) .GE. 35)  GO TO 370
      RELT = T(IZONE) - 35.
      DO 350  J=1,8
         FTN(J) = THKN(J)**RELT
350   CONTINUE
      DO 360  J=1,5
         FTP(J) = THKP(J)**RELT
360   CONTINUE
      GO TO 400
370   DO 380  J=1,8
         FTN(J) = 1.0
380   CONTINUE
      DO 390  J=1,5
         FTP(J) = 1.C
390   CONTINUE
C
400   DO 410  J=1,8
         KNC(J) = KN(J,IZONE)*FTN(J)
410   CONTINUE
      DO 420  J=1,5
         KPC(J) = KP(J,IZONE)*FTP(J)
420   CONTINUE
C
C                           DEVELOP COEFFICIENT ARRAY
C
      C(1,1) = -KNC(4)
      C(1,2) = KNC(5)
      C(1,4) = KNC(6)
      C(2,1) = KNC(4)
      C(2,2) = -(KNC(7) + KNC(1) + KNC(5))
      C(2,3) = KNC(8)
      C(3,2) = KNC(7)
      C(3,3) = -KNC(8)
      C(4,2) = KNC(1)
      C(4,4) = -(KNC(2) + KNC(3) + KNC(6))
      C(5,4) = KNC(2)
      C(6,4) = KNC(3)
C
      C(11,11) = -KPC(1)
      C(11,12) = KPC(2)
      C(12,11) = KPC(1)
      C(12,12) = -(KPC(2) + KPC(4) + KPC(3))
      C(12,13) = KPC(5)
      C(13,12) = KPC(4)
      C(13,13) = -KPC(5)
      C(14,12) = KPC(3)
C
C                           SULUTION
C
      DO 700  IBLK=1,5
         IF(IZONE.EQ.1) GO TO 425
C
         IF (JNFW(IBLK) .LE. 0.000001) GO TO 700
         SMMA = MUZ/(1000000.*AREA)
         WMMAB(IBLK) = JNFW(IBLK)/(1000000.*AREA)
         GO TO 430
C
425      IF (INFW(IBLK) .LE. 0.000001) GO TO 700
         SMMA = M/(1000000.*AREA)
         WMMAB(IBLK) = INFW(IBLK)/(1000000.*AREA)
430        DO 500 IROW = 1,20
C
             SUM = 0.0
             DO 450 ICOL = 1,20
               GO TO (435,440,435,440,450,450,450,450,450,450,435,440,
     1                435,450,450,450,450,450,450,450), ICOL
435            PPMS(ICOL) = NB(ICOL,IBLK)/SMMA
               SCT = C(IROW,ICOL)*PPMS(ICOL)
               LBA = SCT*SMMA
               SUM = SUM + LBA
               GO TO 450
C
440            PPMSW(ICOL) = NB(ICOL,IBLK)/WMMAB(IBLK)
               SWCT = C(IROW,ICOL)*PPMSW(ICOL)
               LBA = SWCT*WMMAB(IBLK)
               SUM = SUM + LBA
450          CONTINUE
           DELNB(IROW,IBLK) = DELT*SUM
500        CONTINUE
         DO 600  J=1,20
            NB(J,IBLK) = NB(J,IBLK) + DELNB(J,IBLK)
            IF (NB(J,IBLK).LT.0.000001) NB(J,IBLK)=0.0
600      CONTINUE
700   CONTINUE
C
      RETURN
      END
C
C
C
C
      SUBROUTINE OUTMCN (YEAR,KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     1 TPBAL,DEGSOM,DEGUOM,DEGLOM,UIST,TOTPAP,TIMAP,YEARAP)
C
C                           THIS SUBROUTINE OUTPUTS MONTHLY
C                           TABLES, AND ZEROS ACCUMULATIONS
C
      INTEGER  YEAR
C
C
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1          STEMP(24),UTEMP(24)
      COMMON /ALL/  RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1          RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN.
     2           M,P3,A,CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,
     3           IMIN,IHR,TF,JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,
     4           ON,OFF,SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTP,METR,
     1           MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
      INTEGER*4  LCOF
C
      REAL  RU,HYMIN,UPST,LZS,AREA,RESB1(5),ROSB(5),SRGX(5),INTF(5),
     1        RGX(5),INFL(5),UZSB(5),APERCB(5),RIB(5),ERSN(5),RESB(5),
     2        M,P3,A,LTEMP,LMOIST,MUZ,MLZ        \
C
      COMMON /LAND/ MNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
     1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
     2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
     4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
     5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
     6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
     7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
     8 MELRAM,RADMEM,CORMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
     9 PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
     * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
     1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
     2 DSNFLO,DSNERS,LSRC,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
C
      DOUBLE PRECISION  MNAM(12)
C
      REAL  PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,RITOM,RINTOM,BASTOM,
     1        RCHTOM,RUTOT,NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,
     2        TWBAL,EPTOM,EPTOT,UZS,UZSN,LZSN,INFIL,INTER,IRC,
     3        NN,L,SS,SGW1,PR,SGW,GWS,KV,K24L,KK24,K24EL,EP,IFS,
     4      K3(12),EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,SRGXT1,JRER,KRER,
     5        JSER,KSER,SRERT,MMPIN,METOPT,  NEPTOM,ROSTOM,
     6        CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,
     7        PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,IPACK,TMIN,SUMSNM,
     9        PXSNM,XK3,MELRAM,RADMEM,CORMEM,CRAINM,SGMM,SNEGMM,SEVAPM,
     A        SUMSNY,PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,
     B        CRAINY,SNEGMY,SEVAPY,TSNBAL,CONMEM,
     C        COVER,COVRMX,ROBTOM(5),ROBTOT(5),RXB(5),ROITOM(5),
     D        ROITOT(5),INFTOM(5),INFTOT(5),ERSTOM(5),ERSTOT(5),
     E        SRER(5),TEMPX(24),RAD(24),WINDX(24),RAIN(288),
     F        LSRC(128),EROS(128),RROS(128)
C
      INTEGER  DAY,MONTH
      INTEGER  DSNERS,DSNROS,DSNFLO,TMBLSZ
C
C
      COMMON /PESTC/
     1 STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
     4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
C
      REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
     2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
     3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
     4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
     5 UPRITT,UPRIS(5)
C
      REAL    KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,TPBAL,
     1        DEGSOM,DEGUOM,DEGLOM,UIST,TOTPAP
C
      INTEGER  TIMAP(12),YEARAP(12)
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,UN,UNT,UNI,UNIT,
     1              UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2              SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3              TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4              KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5              TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      REAL  DELT,
     1         SNT(20),SNRSM(20,5),SNROM(20,5),
     2         UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
     3         NRSM(20,5),LNRPM(20),
     4         SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
     5         SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
     6         LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
     7         TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
     8         KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
      DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
C
C
      INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
C
C                        HYDROLOGY AND PESTICIDE VARIABLES USED
C                        INTERNALLY
C
      REAL  PRT,PRTTOM(5),PRTTOT(5),DEGTOM,
     1         DEGT,PBAL,COVR,PACKMM,TSNBMM,
     2         UZSMET,LZSMET,SGWMET,SCEPMT,RESSMT,TWBLMT,SRGXTM,
     3         SRRTMT,STSTMT,SASTMT,SCSTMT,SDSTMT,UTSTMT,
     4         UASTMT,UCSTMT,UDSTMT,LSTRMT,LASMET,LCSMET,LDSMET,
     5         GSTRMT,GASMET,GCSMET,GDSMET,DEGTMT,DEGSMT,DEGUMT,
     6         DEGLMT,TPBALM,UZSBMT(5),RESBMT(5),SRGXMT(5),
     7         SRERMT(5),STSMET(5),SASMET(5),SCSMET(5),SDSMET(5),
     8         UTSMET(5),UASMET(5),UCSMET(5),UDSMET(5),UPRISM(5)
C
C                        NUTRIENT INTERNAL VARIABLES
C
      DOUBLE PRECISION  CONC, LBPAC, KGPHA
C
      REAL  NBALMT,PHBLMT,CLBLMT,
     1         SNMET(20,5),SNTMET(20),UNMET(20,5),UNTMET(20),
     2         LNMET(20),GNMET(20),SNRSMT(20),SNROMT(20),
     3         UNRIMT(20),SNRBMT(20),UNRBMT(20),NRSMT(20),
     4         NRSYT(20),SNRSYT(20),SNROYT(20),SNRBYT(20),
     5         UNRIYT(20),UNRBYT(20),UNITMT(20),UNIMET(20,5),
     6         TR(20),TNR,TPR,TCLR,TNS,TPS,TCLS,
     7         SUMS,SUMI,SUMB,SUMRS,CONVF
      DATA PRT/0.0/,DEGT/0.0/,LBPAC/'LB/AC'/,KGPHA/'KG/HA'/
      DATA TR/20*0.0/,CONVF/1.121/
C
C
C
C                   MONTHLY SUMMARY
C
          IF (PEST .EQ. NO)  GO TO 973
C
          DO 1051  I= 1,5
 1051     PRTTOM(I) = PRSTOM(I) + PROTOM(I) + UPITOM(I)
C
C
          DEGTOM = DEGSOM + DEGUOM + DEGLOM
          DEGT = DEGT + DEGTOM
C
          PRTM = SPRCTM + SPRSTM + UPRITM
          PRT = PRT + PRTM
C
           PBAL = STST + LTST + LSTR + GSTR + PRT + DEGT - TOTPAP
           IF ((PBAL .LE. 0.0).AND.(PBAL .GE. -0.0020))  PBAL = 0.0
           IF (JCOUNT.LT.TIMAP(1) .AND. YEAR.LE.(YEARAP(1)+1900)) PBAL=0.
          TPBAL = TPBAL + PBAL
C
  973     IF (NUTR .EQ. NO)  GO TO 990
C
C                          COMPUTE MONTHLY NUTRIENT TOTALS BY ZONE,
C                          ACCUMULATE YEARLY REMOVALS,
C                          COMPUTE TOTAL N, P, CL MASS BALANCES
C
C                          SURFACE
      DO 991  J=1,20
         SUMS = 0.0
         SUMO = 0.0
         SUMB = 0.0
         SNT(J) = 0.0
         DO 989  IBLK=1,5
            SUMS = SUMS + SNRSM(J,IBLK)
            SUMO = SUMO + SNROM(J,IBLK)
            SUMB = SUMB + SNRBM(J,IBLK)
            SNT(J) = SNT(J) + SN(J,IBLK)
989      CONTINUE
         SNRSMT(J) = SUMS/5.
         SNROMT(J) = SUMO/5.
         SNRBMT(J) = SUMB/5.
         SNT(J) = SNT(J)/5.
991   CONTINUE
C
C                          UPPER ZONE
C
      DO 993  J=1,20
         SUMI = 0.0
         SUMB = 0.0
         UNT(J) = 0.0
         UNIT(J) = 0.0
         DO 992  IBLK=1,5
            SUMI = SUMI + UNRIM(J,IBLK)
            SUMB = SUMB + UNRBM(J,IBLK)
            UNT(J) = UNT(J) + UN(J,IBLK)
            UNIT(J) = UNIT(J) + UNI(J,IBLK)
992      CONTINUE
         UNRIMT(J) = SUMI/5.
         UNRBMT(J) = SUMB/5.
         UNT(J) = UNT(J)/5.
         UNIT(J) = UNIT(J)/5.
993   CONTINUE
C
C                          TOTAL REMOVAL TO STREAM
C
      DO 995 J=1,20
         SUMRS = 0.0
         DO 994  IBLK=1,5
            SUMRS = SUMRS + NRSM(J,IBLK)
994      CONTINUE
         NRSMT(J) = SUMRS/5.
995   CONTINUE
C
C                          YEARLY ACCUMULATIONS
C
      DO 997  J=1,20
         DO 996  IBLK=1,5
            SNRSY(J,IBLK) = SNRSY(J,IBLK) + SNRSM(J,IBLK)
            SNROY(J,IBLK) = SNROY(J,IBLK) + SNROM(J,IBLK)
            SNRBY(J,IBLK) = SNRBY(J,IBLK) + SNRBM(J,IBLK)
C
            UNRIY(J,IBLK) = UNRIY(J,IBLK) + UNRIM(J,IBLK)
            UNRBY(J,IBLK) = UNRBY(J,IBLK) + UNRBM(J,IBLK)
C
            NRSY(J,IBLK) = NRSY(J,IBLK) + NRSM(J,IBLK)
996      CONTINUE
         LNRPY(J) = LNRPY(J) + LNRPM(J)
```

```
            LNRBY(J) = LNRBY(J) + LNRBM(J)
            GNRBY(J) = GNRBY(J) + GNRBM(J)
            TNRHVY(J) = TNRHVY(J) + TNRHVM(J)
997   CONTINUE
C
C                          MASS BALANCES AND TOTAL REMOVALS
C                          TR(20) = TOTAL REMOVAL OVER SIMULATION PERIOD
C                          TNR = TOTAL NITROGEN REMOVAL
C                          TPR = TOTAL PHOSPHURUS REMOVAL
C                          TCLR = TOTAL CHLORIDE REMOVAL
C                          TNS = TOTAL NITROGEN IN STORAGE
C                          TPS = TOTAL PHOSPHURUS IN STORAGE
C                          TCLS = TOTAL CHLORIDE IN STORAGE
C                          TNA = TOTAL NITROGEN ADDED, AND INITIAL STRG.
C                          TPA = TOTAL PHOSPHORUS ADDED
C                          TCLA = TOTAL CHLORIDE ADDED
C
      DO 503  J=1,20
         SUMB = 0.0
         DO 502  IBLK=1,5
            SUMB = SUMB + NRSM(J,IBLK)
502      CONTINUE
         TR(J) = TR(J) + SUMB/5. + TNRHVM(J)
503   CONTINUE
      TNR = 0.0
      DO 504  J=1,6
         TNR = TNR + TR(J)
504   CONTINUE
      TPR = 0.0
      DO 505  J=11,14
         TPR = TPR + TR(J)
505   CONTINUE
      TCLR = TR(20)
C
      TNS = 0.0
      DO 511  J=1,6
         SUMB = 0.0
         DO 510  IBLK = 1,5
            SUMB = SUMB + SN(J,IBLK) + UN(J,IBLK) + UNI(J,IBLK)
510      CONTINUE
         TNS = TNS + SUMB/5. + LN(J) + GN(J)
511   CONTINUE
      NBAL = TNS + TNR - TNA
C
      TPS = 0.0
      DO 513  J=11,14
         SUMB = 0.0
         DO 512  IBLK=1,5
            SUMB = SUMB + SN(J,IBLK) + UN(J,IBLK) + UNI(J,IBLK)
512      CONTINUE
         TPS = TPS + SUMB/5. + LN(J) + GN(J)
513   CONTINUE
      PHBAL = TPS + TPR - TPA
C
      SUMB = 0.0
      DO 514  IBLK=1,5
         SUMB = SUMB + SN(20,IBLK) + UN(20,IBLK) + UNI(20,IBLK)
514   CONTINUE
      TCLS = SUMB/5. + LN(20) + GN(20)
      CLBAL = TCLS + TCLR - TCLA
C
C
  990       WRITE (6,1200)  MNAM(MONTH), YEAR
            WRITE (6,1201)
            WRITE (6,1103)
C
      IF (OUTPUT.EQ. METR) GO TO 1053
      WRITE (6,360)
      WRITE (6,362)
      WRITE (6,363) ROBTOM, ROSTOM
      WRITE (6,364) INFTOM, RINTOM
      WRITE (6,365) RITOM
      WRITE (6,366) RCITOM, RUTOM
      WRITE (6,380) BASTOM
      WRITE (6,381) RCHTOM
      WRITE (6,361) PRTOM,PRTOM,PRTOM,PRTOM,PRTOM,PRTOM
      IF (SNOW .EQ. NO)  GO TO 1071
      WRITE (6,478) SUMSNM
      WRITE (6,479) PXSNM
      WRITE (6,480) MELRAM
      WRITE (6,481)
      WRITE (6,482) RADMEM
      WRITE (6,483) CCNMEM
      WRITE (6,484) CDRMEM
      WRITE (6,485) CRAINM
      WRITE (6,486) SGMM
      WRITE (6,487) SNEGMM
      WRITE (6,490) PACK
         COVR = 100.
         IF (PACK .LT. IPACK) COVR = (PACK/IPACK)*100.
         IF (PACK.GT.0.01) GO TO 1078
         COVR=0.0
         SDEN=0.0
 1078 WRITE (6,491) SDEN
      WRITE (6,492) COVR
      WRITE (6,488) SEVAPM
 1071 WRITE (6,367)
      WRITE (6,368) EPTOM,EPTOM,EPTOM,EPTOM,EPTOM,EPTOM
      WRITE (6,369) NEPTOM,NEPTOM,NEPTOM,NEPTOM,NEPTOM,NEPTOM
      WRITE (6,383) COVER
      WRITE (6,370)
      WRITE (6,371) LZSB,UZS
      WRITE (6,372) LZS,LZS,LZS,LZS,LZS,LZS
      WRITE (6,373) SGW,SGW,SGW,SGW,SGW,SGW
      WRITE (6,374) SCEP,SCEP,SCEP,SCEP,SCEP,SCEP
      WRITE (6,375) RESB,RESS
      WRITE (6,376) SRGX,SRGXT
      WRITE (6,377) TWBAL
      IF (SNOW.EQ.YES)  WRITE (6,489) TSNBAL
            WRITE (6,1209)
            WRITE (6,1210) ERSTOM,  ERSNTM
            WRITE (6,1211)  SRER, SRERT
C
            IF (PEST .EQ. NO)  GO TO 974
C
            WRITE (6,1220)
            WRITE (6,1221)  STS, STST
            WRITE (6,1222)  SAS, SAST
            WRITE (6,1223)  SCS, SCST
            WRITE (6,1227)  SDS, SDST
            WRITE (6,1224)  UTS, UTST
            WRITE (6,1222)  UAS, UAST
            WRITE (6,1223)  UCS, UCST
            WRITE (6,1227)  UDS, UDST
            WRITE (6,1226)  UPRIS, UIST
            WRITE (6,1228)  LSTR
            WRITE (6,1229)  LAS
            WRITE (6,1230)  LCS
            WRITE (6,1231)  LDS
            WRITE (6,1232)  GSTR
            WRITE (6,1229)  GAS
            WRITE (6,1230)  GCS
            WRITE (6,1231)  GDS
            WRITE (6,1240)  PRTTOM, PRTM
            WRITE (6,1241)  PROTOM, SPROTM
            WRITE (6,1242)  PRSTOM, SPRSTM
            WRITE (6,1243)  UPITOM, UPRITM
```

```
                WRITE (6,1248)
                WRITE (6,1245) DEGTOM
                WRITE (6,1246) DEGSOM
                WRITE (6,1247) DEGUOM
                WRITE (6,1252) DEGLOM
                WRITE (6,1266) TPBAL
C
  974     IF (NUTR .EQ. NO)  GO TO 1053
C
C                              MONTHLY NUTRIENT OUTPUT
C
      CONC = LBPAC
      WRITE (6,1092)
      WRITE (6,4000)  CONC
      WRITE (6,4005)
      WRITE (6,4006)  (SNT(J),J=1,6),(SNT(J),J=11,14),SNT(20)
      WRITE (6,4030) (IBLK,(SN(J,IBLK),J=1,6),(SN(J,IBLK),J=11,14)
     1                ,SN(20,IBLK),  IBLK=1,5)
      WRITE (6,4007)  (UNT(J),J=1,6),(UNT(J),J=11,14),UNT(20)
      WRITE (6,4030) (IBLK,(UN(J,IBLK),J=1,6),(UN(J,IBLK),J=11,14)
     1                ,UN(20,IBLK),  IBLK=1,5)
      WRITE (6,4015)  (UNIT(J),J=1,6),(UNIT(J),J=11,14),UNIT(20)
      WRITE (6,4030) (IBLK,(UNI(J,IBLK),J=1,6),(UNI(J,IBLK),J=11,14),
     1               UNI(20,IBLK),  IBLK=1,5)
      WRITE (6,4008)  (LN(J),J=1,6),(LN(J),J=11,14),LN(20)
      WRITE (6,4009)  (GN(J),J=1,6),(GN(J),J=11,14),GN(20)
C
      WRITE (6,4011)
      WRITE (6,4012)
      WRITE (6,4013)  (SNRSMT(J),J=1,6),(SNRSMT(J),J=11,14),SNRSMT(20)
      WRITE (6,4030) (IBLK,(SNRSM(J,IBLK),J=1,6),
     1               (SNRSM(J,IBLK),J=11,14),
     2               SNRSM(20,IBLK),  IBLK=1,5)
      WRITE (6,4014)  (SNROMT(J),J=1,6),(SNROMT(J),J=11,14),SNROMT(20)
      WRITE (6,4030) (IBLK,(SNROM(J,IBLK),J=1,6),
     1               (SNROM(J,IBLK),J=11,14),
     2               SNROM(20,IBLK),  IBLK=1,5)
      WRITE (6,4015)  (UNRIMT(J),J=1,6),(UNRIMT(J),J=11,14),UNRIMT(20)
      WRITE (6,4030) (IBLK,(UNRIM(J,IBLK),J=1,6),
     1               (UNRIM(J,IBLK),J=11,14),
     2               UNRIM(20,IBLK),  IBLK=1,5)
      WRITE (6,4016)  (NRSMT(J),J=1,6),(NRSMT(J),J=11,14),NRSMT(20)
      WRITE (6,4017)  (LNRPM(J),J=1,6),(LNRPM(J),J=11,14),LNRPM(20)
      WRITE (6,4018)  (TNRBM(J),J=1,6),(TNRBM(J),J=11,14),TNRBM(20),
     1                (SNRBMT(J),J=1,6),(SNRBMT(J),J=11,14),SNRBMT(20),
     2                (UNRBMT(J),J=1,6),(UNRBMT(J),J=11,14),UNRBMT(20),
     3                (LNRBM(J),J=1,6),(LNRBM(J),J=11,14),LNRBM(20),
     4                (GNRBM(J),J=1,6),(GNRBM(J),J=11,14),GNRBM(20)
      WRITE (6,4019)  (TNRHVM(J),J=1,6),(TNRHVM(J),J=11,14),TNRHVM(20)
      WRITE (6,4021)  NBAL, PHBAL, CLBAL
C
C
 1053 IF (OUTPUT.EQ. ENGL) GO TO 1055
C  CONVERSIONS TO METRIC
C  NEW PARAMETERS DEFINED FOR VARIABLES NOT RESET TO ZERO.
C
      PRTOM =PRTOM*MMPIN
      ROSTOM=ROSTOM*MMPIN
      RINTOM=RINTOM*MMPIN
      RITOM =RITOM*MMPIN
      RUTOM =RUTOM*MMPIN
      BASTOM =BASTOM*MMPIN
      RCHTOM=RCHTOM*MMPIN
      EPTOM =EPTOM*MMPIN
      NEPTOM =NEPTOM*MMPIN
      UZSMET=UZS*MMPIN
      LZSMET=LZS*MMPIN
      SGWMET=SGW*MMPIN
      SCEPMT=SCEP*MMPIN
      RESSMT=RESS*MMPIN
      TWBLMT=TWBAL*MMPIN
      SRGXTM=SRGXT*MMPIN
C  SEDIMENT
      ERSNTM=ERSNTM*METOPT*2.471
      SRRTMT=SRERT*METOPT*2.471
C  SNOW
      IF (SNOW .EQ. NO)  GO TO 970
      SUMSNM = SUMSNM*MMPIN
      PXSNM = PXSNM*MMPIN
      MELRAM = MELRAM*MMPIN
      RADMEM = RADMEM*MMPIN
      CONMEM = CONMEM*MMPIN
      CDRMEM = CDRMEM*MMPIN
      CRAINM = CRAINM*MMPIN
      SGMM = SGMM*MMPIN
      SNEGMM = SNEGMM*MMPIN
      PACKMM = PACK*MMPIN
      SEVAPM = SEVAPM*MMPIN
      TSNBMM = TSNBAL*MMPIN
C  PESTICIDE
  970 IF (PEST .EQ. NO)  GO TO 975
      STSTMT=STST*KGPLB
      SASTMT=SAST*KGPLB
      SCSTMT=SCST*KGPLB
      SDSTMT=SDST*KGPLB
      UTSTMT=UTST*KGPLB
      UASTMT=UAST*KGPLB
      UCSTMT=UCST*KGPLB
      UDSTMT=UDST*KGPLB
      UIST=UIST*KGPLB
      LSTRMT=LSTR*KGPLB
      LASMET=LAS*KGPLB
      LCSMET=LCS*KGPLB
      LDSMET=LDS*KGPLB
      GSTRMT=GSTR*KGPLB
      GASMET=GAS*KGPLB
      GCSMET=GDS*KGPLB
      GDSMET=GDS*KGPLB
      PRTM  =PRTM*KGPLB
      SPROTM=SPROTM*KGPLB
      SPRSTM=SPRSTM*KGPLB
      UPRITM=UPRITM*KGPLB
      DEGTMT=DEGTCM*KGPLB
      DEGSMT=DEGSCM*KGPLB
      DEGUMT=DEGUCM*KGPLB
      DEGLMT=DEGLCM*KGPLB
      TPBALM=TPBAL*KGPLB
C
C ARRAY METRIC MODIFICATIONS
  975 DO 1048 I=1,5
        ROBTOM(I)=ROBTOM(I)*MMPIN
        INFTOM(I)=INFTOM(I)*MMPIN
        ROITOM(I)=ROITOM(I)*MMPIN
        UZSBMT(I)=UZSB(I)*MMPIN
        RESBMT(I)=RESB(I)*MMPIN
        SRGXMT(I)=SRGX(I)*MMPIN
        ERSTOM(I)=ERSTOM(I)*METOPT*2.471
        SRERMT(I)=SRER(I)*METOPT*2.471
       IF (PEST .EQ. NO)  GO TO 1048
        STSMET(I)=STS(I)*KGPLB
        SASMET(I)=SAS(I)*KGPLB
        SCSMET(I)=SCS(I)*KGPLB
        SDSMET(I)=SDS(I)*KGPLB
        UTSMET(I)=UTS(I)*KGPLB
        UASMET(I)=UAS(I)*KGPLB
        UCSMET(I)=UCS(I)*KGPLB
        UDSMET(I)=UDS(I)*KGPLB
        UPRISM(I)=UPRIS(I)*KGPLB
        PRTTOM(I)=PRTTOM(I)*KGPLB
        PROTOM(I)=PROTOM(I)*KGPLB
        PRSTOM(I)=PRSTOM(I)*KGPLB
        UPITOM(I)=UPITOM(I)*KGPLB
 1048 CONTINUE
      WRITE (6,460)
      WRITE (6,362)
      WRITE (6,363) RGBTOM,ROSTOM
      WRITE (6,364) INFTOM,RINTOM
      WRITE (6,365) RITOM
      WRITE (6,366) RCITOM,RUTOM
      WRITE (6,380) BASTOM
      WRITE (6,381) RCHTOM
      WRITE (6,381) PRTOM,PRTOM,PRTOM,PRTOM,PRTOM,PRTOM
      IF (SNOW .EQ. NO)  GO TO 1089
      WRITE (6,478)  SUMSNM
      WRITE (6,479)  PXSNM
      WRITE (6,480)  MELRAM
      WRITE (6,481)
      WRITE (6,482)  RADMEM
      WRITE (6,483)  CONMEM
      WRITE (6,484)  CORMEM
      WRITE (6,485)  CRAINM
      WRITE (6,486)  SGMM
      WRITE (6,487)  SNEGMM
      WRITE (6,490)  PACKMM
         COVR = 100.0
         IF (PACK .LT. IPACK)  COVR = (PACK/IPACK)*100.
         IF (PACK .GT. 0.01)  GO TO 1088
         COVR = 0.0
         SDEN = 0.0
 1088 WRITE (6,491)  SDEN
      WRITE (6,492)  COVR
      WRITE (6,488)  SEVAPM
 1089 WRITE (6,367)
      WRITE (6,368) EPTOM,EPTOM,EPTOM,EPTOM,EPTOM,EPTOM
      WRITE (6,369) NEPTOM,NEPTOM,NEPTOM,NEPTOM,NEPTOM,NEPTOM
      WRITE (6,383) COVER
      WRITE (6,370)
      WRITE (6,371) LZSBMT,UZSMET
      WRITE (6,372) LZSMET,LZSMET,LZSMET,LZSMET,LZSMET,LZSMET
      WRITE (6,373) SGWMET,SGWMET,SGWMET,SGWMET,SGWMET,SGWMET
      WRITE (6,374) SCEPMT,SCEPMT,SCEPMT,SCEPMT,SCEPMT,SCEPMT
      WRITE (6,375) RESBMT,RESSMT
      WRITE (6,376) SRGXMT,SRGXTM
      WRITE (6,377) TWBLMT
      IF (SNOW .EQ. YES)  WRITE (6,489)  TSNBMM
      WRITE (6,1208)
      WRITE (6,1210) ERSTOM,ERSNTM
      WRITE (6,1211) SRERMT,SRRTMT
C
        IF (PEST .EQ. NO)  GO TO 976
C
      WRITE (6,1207)
      WRITE (6,1221) STSMET,STSTMT
      WRITE (6,1222) SASMET,SASTMT
      WRITE (6,1223) SCSMET,SCSTMT
      WRITE (6,1227) SDSMET,SDSTMT
      WRITE (6,1224) UTSMET,UTSTMT
      WRITE (6,1222) UASMET,UASTMT
      WRITE (6,1223) UCSMET,UCSTMT
      WRITE (6,1227) UDSMET,UDSTMT
      WRITE (6,1226) UPRISM,UIST
      WRITE (6,1228) LSTRMT
      WRITE (6,1229) LASMET
      WRITE (6,1230) LCSMET
      WRITE (6,1231) LDSMET
      WRITE (6,1232) GSTRMT
      WRITE (6,1229) GASMET
      WRITE (6,1230) GCSMET
      WRITE (6,1231) GDSMET
      WRITE (6,1239) PRTTOM,PRTM
      WRITE (6,1241) PROTOM,SPROTM
      WRITE (6,1242) PRSTOM,SPRSTM
      WRITE (6,1243) UPITOM,UPRITM
      WRITE (6,1249)
      WRITE (6,1245) DEGTMT
      WRITE (6,1246) DEGSMT
      WRITE (6,1247) DEGUMT
      WRITE (6,1252) DEGLMT
      WRITE (6,1266) TPBALM
C
  976 IF (NUTR .EQ. AC)  GO TO 1055
C
C                         CONVF CONVERTS LB/AC TO KG/HA
C
      DO 520  J=1,20
         SNRSMT(J) = SNRSMT(J)*CONVF
         SNROMT(J) = SNROMT(J)*CONVF
         UNRIMT(J) = UNRIMT(J)*CONVF
         NRSMT(J) = NRSMT(J)*CONVF
         LNRPM(J) = LNRPM(J)*CONVF
         TNRBM(J) = TNRBM(J)*CONVF
         SNRBMT(J) = SNRBMT(J)*CONVF
         UNRBMT(J) = UNRBMT(J)*CONVF
         LNRBM(J) = LNRBM(J)*CONVF
         GNRBM(J) = GNRBM(J)*CONVF
         TNRHVM(J) = TNRHVM(J)*CONVF
C
          SNTMET(J) = SNT(J)*CONVF
          UNTMET(J) = UNT(J)*CONVF
          UNITMT(J) = UNIT(J)*CONVF
          LNMET(J) = LN(J)*CONVF
          GNMET(J) = GN(J)*CONVF
         DO 519  IBLK=1,5
            SNRSM(J,IBLK) = SNRSM(J,IBLK)*CONVF
            SNROM(J,IBLK) = SNROM(J,IBLK)*CONVF
           UNRIM(J,IBLK) = UNRIM(J,IBLK)*CONVF
             SNMET(J,IBLK) = SN(J,IBLK)*CONVF
             UNMET(J,IBLK) = UN(J,IBLK)*CONVF
             UNIMET(J,IBLK) = UNI(J,IBLK)*CONVF
519      CONTINUE
520   CONTINUE
      NBALMT = NBAL*CCNVF
      PHBLMT = PHBAL*CONVF
      CLBLMT = CLBAL*CONVF
C
C
      CONC = KGPHA
      WRITE (6,1092)
      WRITE (6,4000)  CONC
      WRITE (6,4005)
      WRITE (6,4006)  (SNTMET(J),J=1,6),(SNTMET(J),J=11,14),SNTMET(20)
      WRITE (6,4030) (IBLK,(SNMET(J,IBLK),J=1,6),(SNMET(J,IBLK),J=11,14)
     1                ,SNMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4007)  (UNTMET(J),J=1,6),(UNTMET(J),J=11,14),UNTMET(20)
      WRITE (6,4030) (IBLK,(UNMET(J,IBLK),J=1,6),(UNMET(J,IBLK),J=11,14)
     1                ,UNMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4015)  (UNITMT(J),J=1,6),(UNITMT(J),J=11,14),UNITMT(20)
      WRITE (6,4030)  (IBLK,(UNIMET(J,IBLK),J=1,6),
     1                (UNIMET(J,IBLK),J=11,14),
     2                UNIMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4008)  (LNMET(J),J=1,6),(LNMET(J),J=11,14),LNMET(20)
      WRITE (6,4009)  (GNMET(J),J=1,6),(GNMET(J),J=11,14),GNMET(20)
C
      WRITE (6,4011)
      WRITE (6,4012)
      WRITE (6,4013)  (SNRSMT(J),J=1,6),(SNRSMT(J),J=11,14),SNRSMT(20)
      WRITE (6,4030) (IBLK,(SNRSM(J,IBLK),J=1,6),
     1               (SNRSM(J,IBLK),J=11,14),
     2               SNRSM(20,IBLK),  IBLK=1,5)
      WRITE (6,4014)  (SNROMT(J),J=1,6),(SNROMT(J),J=11,14),SNROMT(20)
      WRITE (6,4030) (IBLK,(SNROM(J,IBLK),J=1,6),
     1               (SNROM(J,IBLK),J=11,14),
     2               SNROM(20,IBLK),  IBLK=1,5)
      WRITE (6,4015)  (UNRIMT(J),J=1,6),(UNRIMT(J),J=11,14),UNRIMT(20)
      WRITE (6,4030) (IBLK,(UNRIM(J,IBLK),J=1,6),
     1               (UNRIM(J,IBLK),J=11,14),
     2               UNRIM(20,IBLK),  IBLK=1,5)
      WRITE (6,4016)  (NRSMT(J),J=1,6),(NRSMT(J),J=11,14),NRSMT(20)
      WRITE (6,4017)  (LNRPM(J),J=1,6),(LNRPM(J),J=11,14),LNRPM(20)
      WRITE (6,4018)  (TNRBM(J),J=1,6),(TNRBM(J),J=11,14),TNRBM(20),
     1                (SNRBMT(J),J=1,6),(SNRBMT(J),J=11,14),SNRBMT(20),
     2                (UNRBMT(J),J=1,6),(UNRBMT(J),J=11,14),UNRBMT(20),
     3                (LNRBM(J),J=1,6),(LNRBM(J),J=11,14),LNRBM(20),
     4                (GNRBM(J),J=1,6),(GNRBM(J),J=11,14),GNRBM(20)
      WRITE (6,4019)  (TNRHVM(J),J=1,6),(TNRHVM(J),J=11,14),TNRHVM(20)
      WRITE (6,4021)  NBALMT, PHBLMT, CLBLMT
C
C                          ZEROING OF VARIABLES
C
 1055       PRTOM = 0.0
      RUTOM = 0.0
      NEPTOM = 0.0
      ROSTOM = 0.0
      RITOM = 0.0
      RINTOM = 0.0
      BASTOM = 0.0
      RCHTOM = 0.0
             EPTOM = 0.0
             ERSNTM = 0.0
             PRTM = 0.0
             SPROTM = 0.0
             SPRSTM = 0.0
             UPRITM = 0.0
             DEGSOM = 0.0
             DEGUCM = 0.0
             DEGLOM = 0.0
      SUMSNM = 0.0
      PXSNM = 0.0
      MELRAM = 0.0
      RADMEM = 0.0
      CORMEM = 0.0
      CONMEM = 0.0
      CRAINM = 0.0
      SGMM = 0.0
      SNEGMM = 0.0
      SEVAPM = 0.0
C
             DO 1058  I=1,5
                ERSTOM(I) = 0.0
                ROBTOM(I) = 0.0
                INFTOM(I) = 0.0
                PRTTOM(I) = 0.0
                PROTOM(I) = 0.0
                PRSTOM(I) = 0.0
                UPITOM(I) = 0.0
 1058           RGITOM(I)= 0.0
C
         IF (NUTR .EQ. NO)  GO TO 1060
C
```

```
C                                   ZERO MONTHLY ACCUMULATIONS
C
      DO 522  J=1,20
         LNRPM(J) = 0.0
         LNRBM(J) = 0.0
         GNRBM(J) = 0.0
         TNRBM(J) = 0.0
         TNRHVM(J) = 0.0
         DO 521  IBLK=1,5
            SNKSM(J,IBLK) = 0.0
            SNROM(J,IBLK) = 0.0
            UNRIM(J,IBLK) = 0.0
            NRSM(J,IBLK) = 0.0
            SNRBM(J,IBLK) = 0.0
            UNRBM(J,IBLK) = 0.0
521      CONTINUE
522   CONTINUE
C
1060  RETURN
C
C                                   FORMATS
C
 1092 FORMAT ('0')
 1200 FORMAT ('1',25X,'SUMMARY FOR MONTH OF ',A8,1X,I4)
 1201 FORMAT ('+',25X,'__________________________________')
 1103 FORMAT ('0',34X,'BLOCK 1   BLOCK 2   BLOCK 3   BLOCK 4   BLOCK 5',
     C  5X,'TOTAL')
 1208 FORMAT ('0',8X,'SEDIMENT,TONNES/HECTARE')
 1207 FORMAT ('0',5X,'PESTICIDE, KILOGRAMS')
 1209 FORMAT ('0', 8X,'SEDIMENT, TONS/ACRE')
 1210 FORMAT (' ',11X,'ERODED SEDIMENT     ',5(3X,F7.3),4X,F7.3)
 1211 FORMAT (' ',11X,'FINES DEPOSIT',6X,5(3X,F7.3),4X,F7.3)
 1220 FORMAT ('0',5X,'PESTICIDE, POUNDS')
 1221 FORMAT ('0', 8X,'SURFACE LAYER',9X,5(3X,F7.3),3X,F8.3)
 1222 FORMAT (' ',11X,'ADSORBED',11X,5(3X,F7.3),3X,F8.3)
 1223 FORMAT (' ',11X,'CRYSTALLINE',8X,5(3X,F7.3),3X,F8.3)
 1224 FORMAT ('0', 8X,'UPPER ZONE LAYER',6X,5(3X,F7.3),3X,F8.3)
 1226 FORMAT (' ',11X,'INTERFLOW STORAGE',2X,5(2X,F8.3),3X,F8.3)
 1227 FORMAT (' ',11X,'DISSOLVED',10X,5(3X,F7.3),3X,F8.3)
 1228 FORMAT ('0', 8X,'LOWER ZONE LAYER',59X,F8.3)
 1229 FORMAT (' ',11X,'ADSORBED',64X,F8.3)
 1230 FORMAT (' ',11X,'CRYSTALLINE',61X,F8.3)
 1231 FORMAT (' ',11X,'DISSOLVED',63X,F8.3)
 1232 FORMAT ('0', 8X,'GROUNDWATER LAYER',58X,F8.3)
 1239 FORMAT ('0',8X,'PESTICIDE REMOVAL, KGS.',2X,5(F7.3,3X),F8.3)
 1240 FORMAT ('0', 8X,'PESTICIDE REMOVAL, LBS.',2X,5(F7.3,3X),F8.3)
 1241 FORMAT (' ',11X,'OVERLAND FLOW REMOVAL',1X,5(F7.3,3X),F8.3)
 1242 FORMAT (' ',11X,'SEDIMENT REMOVAL',6X,5(F7.3,3X),F8.3)
 1243 FORMAT (' ',11X,'INTERFLOW REMOVAL',5X,5(F7.3,3X),F8.3)
 1245 FORMAT (' ',11X,'TOTAL',68X,F7.3)
 1246 FORMAT (' ',11X,'FROM SURFACE',61X,F7.3)
 1247 FORMAT (' ',11X,'FROM UPPER ZONE',58X,F7.3)
 1248 FORMAT ('0',8X,'PESTICIDE DEGRADATION LOSS, LBS.')
 1249 FORMAT ('0',8X,'PESTICIDE DEGRADATION LOSS, KGS.')
 1252 FORMAT (' ',11X,'FROM LOWER ZONE',58X,F7.3)
 1266 FORMAT ('0',11X,'PESTICIDE BALANCE=',F8.4)
  360 FORMAT ('0',8X,'WATER, INCHES')
  362 FORMAT ('0',11X,'RUNOFF')
  363 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  364 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  365 FORMAT (' ',14X,'IMPERVIOUS',59X,F8.3)
  366 FORMAT (' ',14X,'TOTAL',13X,5(F8.3,2X),1X,F8.3)
  380 FORMAT ('0',11X,'BASE FLOW',63X,F8.3)
  381 FORMAT (' ',11X,'GRDWATER RECHARGE',55X,F8.3)
  361 FORMAT ('0',11X,'PRECIPITATION',8X,5(F7.2,3X),1X,F7.2)
  478 FORMAT (' ',14X,'SNOW',65X,F7.2)
  479 FORMAT (' ',14X,'RAIN ON SNOW',57X,F7.2)
  480 FORMAT (' ',14X,'MELT & RAIN',58X,F7.2)
```

```
      481 FORMAT ('0',11X,'MELT')
      482 FORMAT (' ',14X,'RADIATION',60X,F7.2)
      483 FORMAT (' ',14X,'CONVECTION',59X,F7.2)
      484 FORMAT (' ',14X,'CONDENSATION',57X,F7.2)
      485 FORMAT (' ',14X,'RAIN MELT',60X,F7.2)
      486 FORMAT (' ',14X,'GROUND MELT',58X,F7.2)
      487 FORMAT (' ',14X,'CUM NEG HEAT',57X,F7.2)
      490 FORMAT ('0',11X,'SNOW PACK',63X,F7.2)
      491 FORMAT (' ',11X,'SNOW DENSITY',60X,F7.2)
      492 FORMAT (' ',11X,'% SNOW COVER',60X,F7.2)
      488 FORMAT ('0',11X,'SNOW EVAP',63X,F7.2)
      367 FORMAT ('0',11X,'EVAPOTRANSPIRATION')
      368 FORMAT (' ',14X,'POTENTIAL',9X,5(F7.2,3X),1X,F7.2)
      369 FORMAT (' ',14X,'NET',15X,5(F7.2,3X),1X,F7.2)
      383 FORMAT (' ',14X,'CROP COVER',59X,F7.2)
      370 FORMAT ('0',11X,'STORAGES')
      371 FORMAT (' ',14X,'UPPER ZONE',8X,5(F8.3,2X),1X,F8.3)
      372 FORMAT (' ',14X,'LOWER ZONE',8X,5(F8.3,2X),1X,F8.3)
      373 FORMAT (' ',14X,'GROUNDWATER',7X,5(F8.3,2X),1X,F8.3)
      374 FORMAT (' ',14X,'INTERCEPTION',6X,5(F8.3,2X),1X,F8.3)
      375 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
      376 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
      377 FORMAT ('0',11X,'WATER BALANCE=',F8.4)
      489 FORMAT (' ',11X,'SNOW BALANCE= ',F8.4)
      460 FORMAT ('0',8X,'WATER, MILLIMETERS')
C
C                                  NUTRIENT FORMATS
C
 4000  FORMAT ('0','NUTRIENTS - ',A5,11X,'ORG-N',3X,'NH4-S',3X,'NH4-A',
     1          3X,'NO3+NO2',4X,'N2',2X,'PLNT-N',3X,'ORG-P',3X,
     2          'PO4-S',3X,'PO4-A',2X,'PLNT-P',6X,'CL')
 4005  FORMAT  ('0',3X,'STORAGE')
 4006  FORMAT  ('0',9X,'SURFACE LAYER',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4007  FORMAT  ('0',9X,'UPPER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4008  FORMAT  ('0',9X,'LOWER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4009  FORMAT  ('0',9X,'GROUNDWATER',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4011  FORMAT  ('0',3X,'REMOVAL')
 4012  FORMAT  ('0',6X,'ADVECTIVE')
 4013  FORMAT  ('0',9X,'SEDIMENT',8X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4014  FORMAT  ('0',9X,'OVERLAND FLOW',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4015  FORMAT  ('0',9X,'INTERFLOW',7X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4016  FORMAT  ('0',9X,'TOTAL TO STREAM ',F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4017  FORMAT  ('0',9X,'PERCOLATION TO '/,' ',12X, 'GROUNDWATER',2X,
     1          F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4018  FORMAT  ('0',6X,'BIOLOGICAL - TOTAL ',F8.2,5F8.3,F8.2,3F8.3,F8.3,
     1          /,' ',9X,'SURFACE',9X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     2          /,' ',9X,'UPPER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     3          /,' ',9X,'LOWER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     4          /,' ',9X,'GROUNDWATER',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4019  FORMAT  ('0',6X,'HARVEST',12X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
 4021  FORMAT  ('0',3X,'MASS BALANCE',
     1          /,' ',6X,'NITROGEN   = ',F8.3,
     2          /,' ',6X,'PHOSPHORUS = ',F8.3,
     3          /,' ',6X,'CHLORIDE   = ',F8.3)
 4030  FORMAT (' ',12X,'BLOCK',I2,6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
       END
C
C
C
C
       SUBROUTINE OUTYR (YEAR,KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,
     1 TPBAL,DEGSCT,DEGUCT,DEGLCT,JIST,TIMAP,YEARAP)
C
C                                THIS SUBROUTINE OUTPUTS YEARLY
C                                TABLES, AND ZEROS ACCUMULATIONS

       INTEGER  YEAR
C
```

```
C
      DIMENSION SMOIST(24,5),UMOIST(24,5),LMOIST(24),
     1           STEMP(24),UTEMP(24)
      COMMON /ALL/  RU,HYMIN,PRNTKE,HYCAL,DPST,OUTPUT,TIMFAC,LZS,AREA,
     1            RESB1,ROSB,SRGX,INTF,RGX,INFL,UZSB,APERCB,RIB,ERSN,
     2            M,P3,A,CALB,PROD,PEST,NUTR,ENGL,METR,BOTH,RESB,YES,NO,
     3            IMIN,IHR,TF,JCOUNT,PRINT,INTR,DAYS,HOUR,MNTH,IDEBUG,
     4            ON,OFF,SMOIST,UMOIST,LMOIST,STEMP,UTEMP,LTEMP,MUZ,MLZ
C
      INTEGER  PRNTKE,TIMFAC,IMIN,IHR,TF,JCOUNT
      INTEGER*4  BOTH,CALB,DAYS,ENGL,HOUR,HYCAL,INPUT,INTR,METR,
     1            MNTH,NO,NUTR,OFF,ON,OUTPUT,PEST,PRINT,PROD,SNOW,YES
C
      INTEGER*4  LOOP
C
      REAL  RU,HYMIN,DPST,LZS,AREA,RESB1(5),ROSB(5),SRGX(5),INTF(5),
     1         RGX(5),INFL(5),UZSB(5),APERCB(5),RIB(5),ERSN(5),RESB(5),
     2          M,P3,A,LTEMP,LMOIST,MUZ,MLZ
C
      COMMON /LAND/ PNAM,PRTOT,ERSNTT,PRTOM,ERSNTM,DAY,
     1 RUTOM,NEPTOM,ROSTOM,RITOM,RINTOM,BASTOM,RCHTOM,RUTOT,
     2 NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,TWBAL,EPTOM,EPTOT,
     3 UZS,UZSN,LZSN,INFIL,INTER,IRC,NN,L,SS,SGW1,PR,SGW,GWS,KV,
     4 K24L,KK24,K24EL,EP,IFS,K3,EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,
     5 SRGXT1,JRER,KRER,JSER,KSER,SRERT,MMPIN,METOPT,SNOW,CCFAC,
     6 SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,PETMAX,ELDIF,
     7 DEWX,PACK,DEPTH,MONTH,SDEN,IPACK,TMIN,SUMSNM,PXSNM,XK3,
     8 MELRAM,RADMEM,CORMEM,CRAINM,CONMEM,SGMM,SNEGMM,SEVAPM,SUMSNY,
     9 PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,CRAINY,SNEGMY,SEVAPY,
     * TSNBAL,COVER,COVRMX,ROBTOM,ROBTOT,RXB,ROITOM,ROITOT,INFTOM,
     1 INFTOT,ERSTOM,ERSTOT,SRER,TEMPX,RAD,WINDX,RAIN,INPUT,DSNROS,
     2 DSNFLO,DSNERS,LSRC,EROS,TMBLSZ,LOOP,NEROS,NILSRO,RROS,NRROS
C
      DOUBLE PRECISION  PNAM(12)
C
      REAL  PRTOT,ERSNTT,PRTOM,ERSNTM,RUTOM,RITOM,RINTOM,BASTOM,
     1         RCHTOM,RUTOT,NEPTOT,ROSTOT,RITOT,RINTOT,BASTOT,RCHTOT,
     2         TWBAL,EPTOM,EPTOT,UZS,UZSN,LZSN,INFIL,INTER,IRC,
     3         NN,L,SS,SGW1,PR,SGW,GWS,KV,K24L,KK24,K24EL,EP,IFS,
     4       K3(12),EPXM,RESS1,RESS,SCEP,SCEP1,SRGXT,SRGXT1,JRER,KRER,
     5         JSER,KSER,SRERT,MMPIN,METOPT,   NEPTOM,ROSTOM,,
     6         CCFAC,SCF,IDNS,F,DGM,WC,MPACK,EVAPSN,MELEV,TSNOW,PETMIN,
     7         PETMAX,ELDIF,DEWX,PACK,DEPTH,SDEN,IPACK,TMIN,SUMSNM,
     9         PXSNM,XK3,MELRAM,RADMEM,CORMEM,CRAINM,SGMM,SNEGMM,SEVAPM,
     A         SUMSNY,PXSNY,MELRAY,RADMEY,CORMEY,SGMY,CONMEY,
     B         CRAINY,SNEGMY,SEVAPY,TSNBAL,
     C         COVER,COVRMX,ROBTOM(5),ROBTOT(5),RXB(5),ROITOM(5),
     D         ROITOT(5),INFTOM(5),INFTOT(5),ERSTOM(5),ERSTOT(5),
     E         SRER(5),TEMPX(24),RAD(24),WINDX(24),RAIN(288),
     F         LSRC(128),EROS(128),RROS(128)
C
      INTEGER  DAY,MONTH
      INTEGER  DSNERS,DSNROS,DSNFLO,TMBLSZ
C
C
      COMMON /PESTC/
     1 STST,PRSTOM,SPROTM,PRSTOT,SPRSTM,PROTOM,SAST,PROTOT,
     2 SCST,UPITOM,SDST,UPITOT,UTST,STS,UAST,UTS,UCST,SAS,
     3 UDST,SCS,FP,SDS,CMAX,SSTR1,SPROTT,UAS,SPRSTT,UCS,
     4 FPUZ,UDS,UPRITM,USTR,UPRITT,UPRIS
C
      REAL  STST,PRSTOM(5),SPROTM,PRSTOT(5),SPRSTM,PROTOM(5),SAST,
     2 PROTOT(5),SCST,UPITOM(5),SDST,UPITOT(5),UTST,STS(5),UAST,
     3 UTS(5),UCST,SAS(5),UDST,SCS(5),FP,SDS(5),CMAX,SSTR1(5),
     4 SPROTT,UAS(5),SPRSTT,UCS(5),FPUZ,UDS(5),UPRITM,USTR(5),
     5 UPRITT,UPRIS(5)
C
      REAL    KGPLB,LSTR,LAS,LCS,LDS,GSTR,GAS,GCS,GDS,TPBAL,
     2          DEGSOT,DEGUOT,DEGLOT,DIST
C
      INTEGER  TIMAP(12),YEARAP(12)
C
      COMMON /NUT/  DELT,SN,SNT,SNRSM,SNROM,UN,UNT,UNI,UNIT,
     1              UNRIM,NRSM,LN,LNRPM,GN,SNRBM,UNRBM,LNRBM,GNRBM,TNRBM,
     2              SNRSY,SNROY,UNRIY,NRSY,LNRPY,SNRBY,UNRBY,LNRBY,GNRBY,
     3              TNRBY,TNRHV,TNRHVM,TNRHVY,TNA,TPA,TCLA,
     4              KN,THKN,KP,THKP,NBAL,PHBAL,CLBAL,
     5              TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
      REAL  DELT,
     1          SNT(20),SNRSM(20,5),SNROM(20,5),
     2          UNT(20),UNI(20,5),UNIT(20),UNRIM(20,5),
     3          NRSM(20,5),LNRPM(20),
     4          SNRBM(20,5),UNRBM(20,5),LNRBM(20),GNRBM(20),TNRBM(20),
     5          SNRSY(20,5),SNROY(20,5),UNRIY(20,5),NRSY(20,5),
     6          LNRPY(20),SNRBY(20,5),UNRBY(20,5),LNRBY(20),GNRBY(20),
     7          TNRBY(20),TNRHV(20),TNRHVM(20),TNRHVY(20),TNA,TPA,TCLA,
     8          KN(8,4),THKN(8),KP(5,4),THKP(5),NBAL,PHBAL,CLBAL
      DOUBLE PRECISION  SN(20,5),UN(20,5),LN(20),GN(20)
C
C
      INTEGER  TSTEP,NSTEP,SFLG,UFLG,LFLG,GFLG
C
C
C                         HYDROLOGY AND PESTICIDE VARIABLES USED
C                         INTERNALLY
C
      REAL  PRTT,PRTTOM(5),PRTTOT(5),DEGTOT,
     1          COVR,PACKMY,TSNBMY,
     2          UZSMET,LZSMET,SGWMET,SCEPMT,RESSMT,TWBLMT,SRGXTM,
     3          SRRTMT,STSTMT,SASTMT,SCSTMT,SDSTMT,UTSTMT,
     4          UASTMT,UCSTMT,UDSTMT,LSTRMT,LASMET,LCSMET,LDSMET,
     5          GSTRMT,GASMET,GCSMET,GDSMET,DEGTMT,DEGSMT,DEGUMT,
     6          DEGLMT,TPBALM,UZSBMT(5),RESBMT(5),SRGXMT(5),
     7          SRERMT(5),STSMET(5),SASMET(5),SCSMET(5),SDSMET(5),
     8          UTSMET(5),UASMET(5),UCSMET(5),UDSMET(5),UPRISM(5)
C
C                         NUTRIENT INTERNAL VARIABLES
C
      DOUBLE PRECISION  CONC, LBPAC, KGPHA
C
      REAL  NBALMT,PHBLMT,CLBLMT,
     1          SNMET(20,5),SNTMET(20),UNMET(20,5),UNTMET(20),
     2          LNMET(20),GNMET(20),SNRSMT(20),SNROMT(20),
     3          UNRIMT(20),SNRBMT(20),UNRBMT(20),NRSMT(20),
     4          NRSYT(20),SNRSYT(20),SNROYT(20),SNRBYT(20),
     5          UNRIYT(20),UNRBYT(20),UNITMT(20),UNIMET(20,5),
     7          SUMS,SUMI,SUMB,SUMRS,CONVF
      DATA LBPAC/'LB/AC'/,KGPHA/'KG/HA'/,CONVF/1.121/
C
C                         YEARLY OUTPUT
C
      IF (PEST .EQ. NO)  GO TO 981
            DO 1061  I= 1,5
 1061       PRTTOT(I) = PRSTOT(I) + PROTOT(I) + UPITOT(I)
C
            DEGTOT = DEGSOT + DEGUOT + DEGLOT
C
            PRTT = SFROTT + SPRSTT + UPRITT
C
  981 IF (NUTR .EQ. NO)  GO TO 977
      DO 526  J=1,20
         SUMS = 0.0
         SUMO = 0.0
         SUMB = 0.0
         DO 523  IBLK=1,5
```

```
            SUMS = SUMS + SNRSY(J,IBLK)
            SUMO = SUMO + SNROY(J,IBLK)
            SUMB = SUMB + SNRBY(J,IBLK)
523      CONTINUE
         SNRSYT(J) = SUMS/5.
         SNROYT(J) = SUMO/5.
         SNRBYT(J) = SUMB/5.
C
         SUMI = 0.0
         SUMB = 0.0
         DO 524  IBLK=1,5
            SUMI = SUMI + UNRIY(J,IBLK)
            SUMB = SUMB + UNRBY(J,IBLK)
524      CONTINUE
         UNRIYT(J) = SUMI/5.
         UNRBYT(J) = SUMB/5.
         TNRBY(J) = SNRBYT(J) + UNRBYT(J) + LNRBY(J) + GNRBY(J)
C
         SUMRS = 0.0
         DO 525  IBLK=1,5
            SUMRS = SUMRS + NRSY(J,IBLK)
525      CONTINUE
         NRSYT(J) = SUMRS/5.
526   CONTINUE
C
C
  977    WRITE (6,1250)  YEAR
         WRITE (6,1251)
         WRITE (6,1103)
C
      IF (OUTPUT.EQ. METR) GO TO 1066
      WRITE (6,360)
      WRITE (6,362)
      WRITE (6,363) ROBTOT, ROSTOT
      WRITE (6,364) INFTOT, RINTOT
      WRITE (6,365) RITOT
      WRITE (6,366) ROITOT, RUTOT
      WRITE (6,380) BASTOT
      WRITE (6,381) RCHTOT
      WRITE (6,361) PRTOT,PRTOT,PRTOT,PRTOT,PRTOT,PRTOT
C
      IF (SNOW .EQ. NO)  GO TO 1072
      WRITE (6,478) SUMSNY
      WRITE (6,479) PXSNY
      WRITE (6,480) MELRAY
      WRITE (6,481)
      WRITE (6,482) RADMEY
      WRITE (6,483) CONMEY
      WRITE (6,484) CORMEY
      WRITE (6,485) CRAINY
      WRITE (6,486) SGMY
      WRITE (6,487) SNEGMY
      WRITE (6,490) PACK
         COVR = 100.
         IF (PACK .LT. IPACK) COVR = (PACK/IPACK)*100.
         IF (PACK.GT.0.01) GO TO 1074
         COVR=0.0
         SDEN=0.0
 1074 WRITE (6,491) SDEN
      WRITE (6,492) COVR
      WRITE (6,488) SEVAPY
 1072 WRITE (6,367)
      WRITE (6,368) EPTOT,EPTOT,EPTOT,EPTOT,EPTOT,EPTOT
      WRITE (6,369) NEPTOT,NEPTOT,NEPTOT,NEPTOT,NEPTOT,NEPTOT
      WRITE (6,383) COVER
      WRITE (6,370)
      WRITE (6,371) UZSB,UZS
      WRITE (6,372) LZS,LZS,LZS,LZS,LZS,LZS
      WRITE (6,373) SGW,SGW,SGW,SGW,SGW,SGW
      WRITE (6,374) SCEP,SCEP,SCEP,SCEP,SCEP,SCEP
      WRITE (6,375) RESB,RESS
      WRITE (6,376) SRGX,SRGXT
      WRITE (6,377) TWBAL
      IF (SNOW.EQ.YES)  WRITE (6,489) TSNBAL
         WRITE (6,1209)
         WRITE (6,1210) ERSTOT,  ERSNTT
         WRITE (6,1211)  SRER, SRERT
C
            IF (PEST .EQ. NO)  GO TO 978
C
         WRITE (6,1220)
         WRITE (6,1221)  STS, STST
         WRITE (6,1222)  SAS, SAST
         WRITE (6,1223)  SCS, SCST
         WRITE (6,1227) SDS, SDST
         WRITE (6,1224)  UTS, UTST
         WRITE (6,1222)  UAS, UAST
         WRITE (6,1223)  UCS, UCST
         WRITE (6,1227)  UDS, UDST
         WRITE (6,1226)  UPRIS, JIST
         WRITE (6,1228)  LSTR
         WRITE (6,1229)  LAS
         WRITE (6,1230)  LCS
         WRITE (6,1231)  LDS
         WRITE (6,1232)  GSTR
         WRITE (6,1229)  GAS
         WRITE (6,1230)  GCS
         WRITE (6,1231)  GDS
         WRITE (6,1240)  PRTTOT, PRTT
         WRITE (6,1241)  PRCTOT, SPROTT
         WRITE (6,1242)  PRSTOT, SPRSTT
         WRITE (6,1243)  UPITOT, UPRITT
         WRITE (6,1248)
         WRITE (6,1245) DEGTOT
         WRITE (6,1246) DEGSOT
         WRITE (6,1247) DEGUOT
         WRITE (6,1252) DEGLOT
         WRITE (6,1266) TPBAL
C
  978 IF (NUTR .EQ. NO)  GO TO 1066
C
C                                YEARLY NUTRIENT OUTPUT
C
C
      CONC = LBPAC
      WRITE (6,1092)
      WRITE (6,4000)  CONC
C
      WRITE (6,4005)
      WRITE (6,4006)  (SNT(J),J=1,6),(SNT(J),J=11,14),SNT(20)
      WRITE (6,4030) (IBLK,(SN(J,IBLK),J=1,6),(SN(J,IBLK),J=11,14)
     1                ,SN(20,IBLK),  IBLK=1,5)
      WRITE (6,4007)  (UNT(J),J=1,6),(UNT(J),J=11,14),UNT(20)
      WRITE (6,4030) (IBLK,(UN(J,IBLK),J=1,6),(UN(J,IBLK),J=11,14)
     1                ,UN(20,IBLK),  IBLK=1,5)
      WRITE (6,4015)  (UNIT(J),J=1,6),(UNIT(J),J=11,14),UNIT(20)
      WRITE (6,4030) (IBLK,(UNI(J,IBLK),J=1,6),(UNI(J,IBLK),J=11,14),
     1               UNI(20,IBLK),  IBLK=1,5)
      WRITE (6,4008)  (LN(J),J=1,6),(LN(J),J=11,14),LN(20)
      WRITE (6,4009)  (GN(J),J=1,6),(GN(J),J=11,14),GN(20)
C
      WRITE (6,4011)
      WRITE (6,4012)
      WRITE (6,4013)  (SNRSYT(J),J=1,6),(SNRSYT(J),J=11,14),SNRSYT(20)
      WRITE (6,4030) (IBLK,(SNRSY(J,IBLK),J=1,6),
     1                (SNRSY(J,IBLK),J=11,14),
     2               SNRSY(20,IBLK),   IBLK=1,5)
      WRITE (6,4014)  (SNROYT(J),J=1,6),(SNROYT(J),J=11,14),SNROYT(20)
      WRITE (6,4030) (IBLK,(SNROY(J,IBLK),J=1,6),
     1               (SNROY(J,IBLK),J=11,14),
     2               SNROY(20,IBLK),   IBLK=1,5)
      WRITE (6,4015)  (UNRIYT(J),J=1,6),(UNRIYT(J),J=11,14),UNRIYT(20)
      WRITE (6,4030) (IBLK,(UNRIY(J,IBLK),J=1,6),
     1               (UNRIY(J,IBLK),J=11,14),
     2               UNRIY(20,IBLK),   IBLK=1,5)
      WRITE (6,4016)  (NRSYT(J),J=1,6),(NRSYT(J),J=11,14),NRSYT(20)
      WRITE (6,4017)  (LNRPY(J),J=1,6),(LNRPY(J),J=11,14),LNRPY(20)
      WRITE (6,4018)  (TNRBY(J),J=1,6),(TNRBY(J),J=11,14),TNRBY(20),
     1                (SNRBYT(J),J=1,6),(SNRBYT(J),J=11,14),SNRBYT(20),
     2                (UNRBYT(J),J=1,6),(UNRBYT(J),J=11,14),UNRBYT(20),
     3                (LNRBY(J),J=1,6),(LNRBY(J),J=11,14),LNRBY(20),
     4                (GNRBY(J),J=1,6),(GNRBY(J),J=11,14),GNRBY(20)
      WRITE (6,4019)  (TNRHVY(J),J=1,6),(TNRHVY(J),J=11,14),TNRHVY(20)
      WRITE (6,4021)  NBAL, PHBAL, CLBAL
C
C
 1066 IF (OUTPUT .EQ. ENGL) GO TO 1065
C  CONVERSIONS
      PRTOT =PRTOT*MMPIN
      ROSTOT=ROSTOT*MMPIN
      RINTOT=RINTOT*MMPIN
      RITOT =RITOT*MMPIN
      RUTOT =RUTOT*MMPIN
      BASTOT=BASTOT*MMPIN
      RCHTOT=RCHTOT*MMPIN
      EPTOT =EPTOT*MMPIN
      NEPTOT=NEPTOT*MMPIN
      UZSMET=UZS*MMPIN
      LZSMET=LZS*MMPIN
      SGWMET=SGW*MMPIN
      SCEPMT=SCEP*MMPIN
      RESSMT=RESS*MMPIN
      TWBLMT=TWBAL*MMPIN
      SRGXTM=SRGXT*MMPIN
      ERSNTT=ERSNTT*METOPT*2.471
      SRRTMT=SRERT*METOPT*2.471
C  SNOW
      IF (SNOW .EQ. NO)  GO TO 982
      SUMSNY = SUMSNY*MMPIN
      PXSNY = PXSNY*MMPIN
      MELRAY = MELRAY*MMPIN
      RADMEY = RADMEY*MMPIN
      CONMEY = CONMEY*MMPIN
      CDRMEY = CDRMEY*MMPIN
      CRAINY = CRAINY*MMPIN
      SGMY = SGMY*MMPIN
      SNEGMY = SNEGMY*MMPIN
      PACKMY = PACK*MMPIN
      SEVAPY = SEVAPY*MMPIN
      TSNBMY = TSNBAL*MMPIN
C  PESTICIDE
  982 IF (PEST .EQ. NO)  GO TO 979
      STSTMT=STST*KGPLB
      SASTMT=SAST*KGPLB
      SCSTMT=SCST*KGPLB
      SDSTMT=SDST*KGPLB
      UTSTMT=UTST*KGPLB
      UASTMT=UAST*KGPLB
      UCSTMT=UCST*KGPLB
      UDSTMT=UDST*KGPLB
      UIST=UIST*KGPLB
      LSTRMT=LSTR*KGPLB
      LASMET=LAS*KGPLB
      LCSMET=LCS*KGPLB
     LDSMET=LDS*KGPLB
     GSTRMT=GSTR*KGPLB
     GASMET=GAS*KGPLB
     GCSMET=GCS*KGPLB
     GDSMET=GDS*KGPLB
     PRTT  =PRTT*KGPLB
     SPROTT=SPROTT*KGPLB
     SPRSTT=SPRSTT*KGPLB
     UPRITT=UPRITT*KGPLB
     DEGTMT=DEGTOT*KGPLB
     DEGSMT=DEGSOT*KGPLB
     DEGUMT=DEGUOT*KGPLB
     DEGLMT=DEGLOT*KGPLB
     TPBALM=TPBAL*KGPLB
C  METRIC MODIFICATION OF ARRAYS
  979 DO 1062 I=1,5
       ROBTOT(I)=ROBTOT(I)*MMPIN
       INFTOT(I)=INFTOT(I)*MMPIN
       ROITOT(I)=ROITOT(I)*MMPIN
       UZSBMT(I)=UZSB(I)*MMPIN
       RESBMT(I)=RESB(I)*MMPIN
       SRGXMT(I)=SRGX(I)*MMPIN
       EPSTOT(I)=ERSTOT(I)*METOPT*2.471
       SRERMT(I)=SRER(I)*METOPT*2.471
         IF (PEST .EQ. NO)  GO TO 1062
       STSMET(I)=STS(I)*KGPLB
       SASMET(I)=SAS(I)*KGPLB
       SCSMET(I)=SCS(I)*KGPLB
       SDSMET(I)=SDS(I)*KGPLB
       UTSMET(I)=UTS(I)*KGPLB
       UASMET(I)=UAS(I)*KGPLB
       UCSMET(I)=UCS(I)*KGPLB
       UDSMET(I)=UDS(I)*KGPLB
       UPRISM(I)=UPRIS(I)*KGPLB
       PRTTOT(I)=PRTTOT(I)*KGPLB
       PROTOT(I)=PROTOT(I)*KGPLB
       PRSTOT(I)=PRSTOT(I)*KGPLB
       UPITOT(I)=UPITOT(I)*KGPLB
 1062 CONTINUE
C
     WRITE (6,460)
     WRITE (6,362)
     WRITE (6,363) ROBTOT,ROSTOT
     WRITE (6,364) INFTOT,RINTOT
     WRITE (6,365) RITOT
     WRITE (6,366) ROITOT,RUTOT
     WRITE (6,380) BASTOT
     WRITE (6,381) RCHTOT
     WRITE (6,361) PRTOT,PRTOT,PRTOT,PRTOT,PRTOT,PRTOT
     IF (SNOW .EQ. NO)  GO TO 1089
     WRITE (6,478)  SUMSNY
     WRITE (6,479)  FXSNY
     WRITE (6,480)  MELRAY
     WRITE (6,481)
     WRITE (6,482)  RADMEY
     WRITE (6,483)  CONMEY
     WRITE (6,484)  CDRMEY
     WRITE (6,485)  GRAINY
     WRITE (6,486)  SGMY
     WRITE (6,487)  SNEGMY
     WRITE (6,490)  PACKMY
       COVR = 100.0
       IF (PACK .LT. IPACK)  COVR = (PACK/IPACK)*100.
       IF (PACK .GT. 0.01)  GO TO 1088
       COVR = 0.0
       SDEN = 0.0
 1088 WRITE (6,491)  SDEN
     WRITE (6,492)  COVR
```

```
      WRITE (6,488)  SEVAPY
 1089 WRITE (6,367)
      WRITE (6,368) EPTOT,EPTOT,EPTOT,EPTOT,EPTOT,EPTOT
      WRITE (6,369) NEPTOT,NEPTOT,NEPTOT,NEPTOT,NEPTOT,NEPTOT
      WRITE (6,383) CCVER
      WRITE (6,370)
      WRITE (6,371) UZSBMT,UZSMET
      WRITE (6,372) LZSMET,LZSMET,LZSMET,LZSMET,LZSMET,LZSMET
      WRITE (6,373) SGWMET,SGWMET,SGWMET,SGWMET,SGWMET,SGWMET
      WRITE (6,374) SCEPMT,SCEPMT,SCEPMT,SCEPMT,SCEPMT,SCEPMT
      WRITE (6,375) RESBMT,RESSMT
      WRITE (6,376) SRGXMT,SRGXTM
      WRITE (6,377) TWBLMT
      IF (SNOW .EQ. YES)  WRITE (6,489)  TSNBMY
      WRITE (6,1208)
      WRITE (6,1210) ERSTOT,ERSNTT
      WRITE (6,1211) SRERMT,SRRTMT
C
        IF (PEST .EQ. NO)  GO TO 980
C
      WRITE (6,1207)
      WRITE (6,1221) STSMET,STSTMT
      WRITE (6,1222) SASMET,SASTMT
      WRITE (6,1223) SCSMET,SCSTMT
      WRITE (6,1227) SDSMET,SDSTMT
      WRITE (6,1224) UTSMET,UTSTMT
      WRITE (6,1222) UASMET,UASTMT
      WRITE (6,1223) UCSMET,UCSTMT
      WRITE (6,1227) UDSMET,UDSTMT
      WRITE (6,1226) UPRISM,UIST
      WRITE (6,1228) LSTRMT
      WRITE (6,1229) LASMET
      WRITE (6,1230) LCSMET
      WRITE (6,1231) LDSMET
      WRITE (6,1232) GSTRMT
      WRITE (6,1229) GASMET
      WRITE (6,1230) GCSMET
      WRITE (6,1231) GDSMET
      WRITE (6,1239) PRTTOT,PRTT
      WRITE (6,1241) PROTOT,SPROTT
      WRITE (6,1242) PRSTOT,SPRSTT
      WRITE (6,1243) UPITOT,UPRITT
      WRITE (6,1249)
      WRITE (6,1245) DEGTMT
      WRITE (6,1246) DEGSMT
      WRITE (6,1247) DEGUMT
      WRITE (6,1252) DEGLMT
      WRITE (6,1266) TPBALM
C
C
  980 IF (NUTR .EQ. NO)  GO TO 1065
C
C                            CONVF CONVERTS LB/AC TO KG/HA
C
      DO 530  J=1,20
         SNRSYT(J) = SNRSYT(J)*CONVF
         SNROYT(J) = SNROYT(J)*CONVF
         UNRIYT(J) = UNRIYT(J)*CONVF
         NRSYT(J) = NRSYT(J)*CONVF
         LNRPY(J) = LNRPY(J)*CONVF
         TNRBY(J) = TNRBY(J)*CONVF
         SNRBYT(J) = SNRBYT(J)*CONVF
         UNRBYT(J) = UNRBYT(J)*CONVF
         LNPBY(J) = LNRBY(J)*CONVF
         GNPBY(J) = GNRBY(J)*CONVF
         TNRHVY(J) = TNRHVY(J)*CONVF
C
```

```
          SNTMET(J) = SNT(J)*CONVF
          UNTMET(J) = UNT(J)*CONVF
          UNITMT(J) = UNIT(J)*CONVF
          LNMET(J) = LN(J)*CONVF
          GNMET(J) = GN(J)*CONVF
         DO 529  IBLK=1,5
            SNRSY(J,IBLK) = SNRSY(J,IBLK)*CONVF
            SNROY(J,IBLK) = SNROY(J,IBLK)*CONVF
            UNRIY(J,IBLK) = UNRIY(J,IBLK)*CONVF
             SNMET(J,IBLK) = SN(J,IBLK)*CONVF
             UNMET(J,IBLK) = UN(J,IBLK)*CONVF
             UNIMET(J,IBLK) = UNI(J,IBLK)*CONVF
529      CONTINUE
530   CONTINUE
      NBALMT = NBAL*CONVF
      PHBLMT = PHBAL*CONVF
      CLBLMT = CLBAL*CONVF
C
C
      CONC = KGPHA
      WRITE (6,1092)
      WRITE (6,4000)  CONC
C
      WRITE (6,4005)
      WRITE (6,4006)  (SNTMET(J),J=1,6),(SNTMET(J),J=11,14),SNTMET(20)
      WRITE (6,4030) (IBLK,(SNMET(J,IBLK),J=1,6),(SNMET(J,IBLK),J=11,14)
     1               ,SNMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4007)  (UNTMET(J),J=1,6),(UNTMET(J),J=11,14),UNTMET(20)
      WRITE (6,4030) (IBLK,(UNMET(J,IBLK),J=1,6),(UNMET(J,IBLK),J=11,14)
     1               ,UNMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4015)  (UNITMT(J),J=1,6),(UNITMT(J),J=11,14),UNITMT(20)
      WRITE (6,4030)  (IBLK,(UNIMET(J,IBLK),J=1,6),
     1                (UNIMET(J,IBLK),J=11,14),
     2                UNIMET(20,IBLK),  IBLK=1,5)
      WRITE (6,4008)  (LNMET(J),J=1,6),(LNMET(J),J=11,14),LNMET(20)
      WRITE (6,4009)  (GNMET(J),J=1,6),(GNMET(J),J=11,14),GNMET(20)
C
      WRITE (6,4011)
      WRITE (6,4012)
      WRITE (6,4013)  (SNRSYT(J),J=1,6),(SNRSYT(J),J=11,14),SNRSYT(20)
      WRITE (6,4030) (IBLK,(SNRSY(J,IBLK),J=1,6),
     1               (SNRSY(J,IBLK),J=11,14),
     2               SNRSY(20,IBLK),  IBLK=1,5)
      WRITE (6,4014)  (SNROYT(J),J=1,6),(SNROYT(J),J=11,14),SNROYT(20)
      WRITE (6,4030) (IBLK,(SNROY(J,IBLK),J=1,6),
     1               (SNROY(J,IBLK),J=11,14),
     2               SNROY(20,IBLK),  IBLK=1,5)
      WRITE (6,4015)  (UNRIYT(J),J=1,6),(UNRIYT(J),J=11,14),UNRIYT(20)
      WRITE (6,4030) (IBLK,(UNRIY(J,IBLK),J=1,6),
     1               (UNRIY(J,IBLK),J=11,14),
     2               UNRIY(20,IBLK),  IBLK=1,5)
      WRITE (6,4016)  (NRSYT(J),J=1,6),(NRSYT(J),J=11,14),NRSYT(20)
      WRITE (6,4017)  (LNRPY(J),J=1,6),(LNRPY(J),J=11,14),LNRPY(20)
      WRITE (6,4018)  (TNRBY(J),J=1,6),(TNRBY(J),J=11,14),TNRBY(20),
     1                (SNRBYT(J),J=1,6),(SNRBYT(J),J=11,14),SNRBYT(20),
     2                (UNRBYT(J),J=1,6),(UNRBYT(J),J=11,14),UNRBYT(20),
     3                (LNRBY(J),J=1,6),(LNRBY(J),J=11,14),LNRBY(20),
     4                (GNRBY(J),J=1,6),(GNRBY(J),J=11,14),GNRBY(20)
      WRITE (6,4019)  (TNRHVY(J),J=1,6),(TNRHVY(J),J=11,14),TNRHVY(20)
      WRITE (6,4021)  NBALMT, PHBLMT, CLBLMT
C
C                    ZEROING OF VARIABLES
C
 1065    PRTOT = 0.0
      RUTOT = 0.0
      NEPTOT = 0.0
      POSTOT = 0.0
      RITOT = 0.0
```

Reproduced from
best available copy.

```
      RINTOT = 0.0
      BASTOT = 0.0
      RCHTOT = 0.0
         EPTOT = 0.0
         ERSNTT = 0.0
         PRTT = 0.0
         SPROTT = 0.0
         SPRSTT = 0.0
         UPRITT = 0.0
         DEGSOT = 0.0
         DEGUOT = 0.0
         DEGLOT = 0.0
      SUMSNY = 0.0
      PXSNY = 0.0
      MELRAY = 0.0
      RADMEY = 0.0
      CDRMEY = 0.0
      CONMEY = 0.0
      CRAINY = 0.0
      SGMY = 0.0
      SNEGMY = 0.0
      SEVAPY = 0.0
C
         DO 1068  I=1,5
            ERSTOT(I) = 0.0
            PUBTOT(I) = 0.0
            INFTOT(I) = 0.0
            PRTTOT(I) = 0.0
            PRSTOT(I) = 0.0
            PRUTOT(I) = 0.0
            UPITOT(I) = 0.0
 1068       ROITOT(I) = 0.0
C
      IF (NUTR .EQ. NO)  GO TO 1070
C
C                           ZERO YEARLY NUTRIENT ACCUMULATIONS
C
      DO 534  J=1,20
         LNRPY(J) = 0.0
         LNRBY(J) = 0.0
         GNRBY(J) = 0.0
         TNRBY(J) = 0.0
         TNRHVY(J) = 0.0
         DO 533  IBLK=1,5
            SNRSY(J,IBLK) = 0.0
            SNROY(J,IBLK) = 0.0
            UNRIY(J,IBLK) = 0.0
            NRSY(J,IBLK) = 0.0
            SNRBY(J,IBLK) = 0.0
            UNRSY(J,IBLK) = 0.0
533      CONTINUE
534   CONTINUE
C
1070  RETURN
C
C
C                           FORMATS
C
 1092 FORMAT ('0')
 1103 FORMAT ('0',34X,'BLOCK 1   BLOCK 2   BLOCK 3   BLOCK 4   BLOCK 5',
     C  5X,'TOTAL')
 1208 FORMAT ('0',8X,'SEDIMENT,TONNES/HECTARE')
 1207 FORMAT ('0',5X,'PESTICIDE, KILOGRAMS')
 1209 FORMAT ('0', 8X,'SEDIMENT, TONS/ACRE')
 1210 FORMAT (' ',11X,'ERODED SEDIMENT    ',5(3X,F7.3),4X,F7.3)
 1211 FORMAT (' ',11X,'FINES DEPOSIT',6X,5(3X,F7.3),4X,F7.3)
 1220 FORMAT ('0',5X,'PESTICIDE, POUNDS')
 1221 FORMAT ('0', 8X,'SURFACE LAYER',9X,5(3X,F7.3),3X,F8.3)
 1222 FORMAT (' ',11X,'ADSORBED',11X,5(3X,F7.3),3X,F8.3)
 1223 FORMAT (' ',11X,'CRYSTALLINE',8X,5(3X,F7.3),3X,F8.3)
 1224 FORMAT ('0', 8X,'UPPER ZONE LAYER',6X,5(3X,F7.3),3X,F8.3)
 1226 FORMAT (' ',11X,'INTERFLOW STORAGE',2X,5(2X,F8.3),3X,F8.3)
 1227 FORMAT (' ',11X,'DISSOLVED',10X,5(3X,F7.3),3X,F8.3)
 1228 FORMAT ('0', 8X,'LOWER ZONE LAYER',59X,F8.3)
 1229 FORMAT (' ',11X,'ADSORBED',64X,F8.3)
 1230 FORMAT (' ',11X,'CRYSTALLINE',61X,F8.3)
 1231 FORMAT (' ',11X,'DISSOLVED',63X,F8.3)
 1232 FORMAT ('0', 8X,'GROUNDWATER LAYER',58X,F8.3)
 1239 FORMAT ('0',8X,'PESTICIDE REMOVAL, KGS.',2X,5(F7.3,3X),F8.3)
 1240 FORMAT ('0', 8X,'PESTICIDE REMOVAL, LBS.',2X,5(F7.3,3X),F8.3)
 1241 FORMAT (' ',11X,'OVERLAND FLOW REMOVAL',1X,5(F7.3,3X),F8.3)
 1242 FORMAT (' ',11X,'SEDIMENT REMOVAL',6X,5(F7.3,3X),F8.3)
 1243 FORMAT (' ',11X,'INTERFLOW REMOVAL',5X,5(F7.3,3X),F8.3)
 1245 FORMAT (' ',11X,'TOTAL',68X,F7.3)
 1246 FORMAT (' ',11X,'FROM SURFACE',61X,F7.3)
 1247 FORMAT (' ',11X,'FROM UPPER ZONE',58X,F7.3)
 1248 FORMAT ('0',8X,'PESTICIDE DEGRADATION LOSS, LBS.')
 1249 FORMAT ('0',8X,'PESTICIDE DEGRADATION LOSS, KGS.')
 1250 FORMAT ('1',25X,'SUMMARY FOR ',I4)
 1251 FORMAT ('+',25X,'________________')
 1252 FORMAT (' ',11X,'FROM LOWER ZONE',58X,F7.3)
 1266 FORMAT ('0',11X,'PESTICIDE BALANCE=',F8.4)
  360 FORMAT ('0',8X,'WATER, INCHES')
  362 FORMAT ('0',11X,'RUNOFF')
  363 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  364 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  365 FORMAT (' ',14X,'IMPERVIOUS',59X,F8.3)
  366 FORMAT (' ',14X,'TOTAL',13X,5(F8.3,2X),1X,F8.3)
  380 FORMAT ('0',11X,'BASE FLOW',63X,F8.3)
  381 FORMAT (' ',11X,'GRDWATER RECHARGE',55X,F8.3)
  361 FORMAT ('0',11X,'PRECIPITATION',8X,5(F7.2,3X),1X,F7.2)
  478 FORMAT (' ',14X,'SNOW',65X,F7.2)
  479 FORMAT (' ',14X,'RAIN ON SNOW',57X,F7.2)
  480 FORMAT (' ',14X,'MELT & RAIN',58X,F7.2)
  481 FORMAT ('0',11X,'MELT')
  482 FORMAT (' ',14X,'RADIATION',60X,F7.2)
  483 FORMAT (' ',14X,'CONVECTION',59X,F7.2)
  484 FORMAT (' ',14X,'CONDENSATION',57X,F7.2)
  485 FORMAT (' ',14X,'RAIN MELT',60X,F7.2)
  486 FORMAT (' ',14X,'GROUND MELT',58X,F7.2)
  487 FORMAT (' ',14X,'CUM NEG HEAT',57X,F7.2)
  490 FORMAT ('0',11X,'SNOW PACK',55X,F7.2)
  491 FORMAT (' ',11X,'SNOW DENSITY',60X,F7.2)
  492 FORMAT (' ',11X,'% SNOW COVER',60X,F7.2)
  488 FORMAT ('0',11X,'SNOW EVAP',63X,F7.2)
  367 FORMAT ('0',11X,'EVAPOTRANSPIRATION')
  368 FORMAT (' ',14X,'POTENTIAL',9X,5(F7.2,3X),1X,F7.2)
  369 FORMAT (' ',14X,'NET',15X,5(F7.2,3X),1X,F7.2)
  383 FORMAT (' ',14X,'CROP COVER',59X,F7.2)
  370 FORMAT ('0',11X,'STORAGES')
  371 FORMAT (' ',14X,'UPPER ZONE',8X,5(F8.3,2X),1X,F8.3)
  372 FORMAT (' ',14X,'LOWER ZONE',8X,5(F8.3,2X),1X,F8.3)
  373 FORMAT (' ',14X,'GROUNDWATER',7X,5(F8.3,2X),1X,F8.3)
  374 FORMAT (' ',14X,'INTERCEPTION',6X,5(F8.3,2X),1X,F8.3)
  375 FORMAT (' ',14X,'OVERLAND FLOW',5X,5(F8.3,2X),1X,F8.3)
  376 FORMAT (' ',14X,'INTERFLOW',9X,5(F8.3,2X),1X,F8.3)
  377 FORMAT ('0',11X,'WATER BALANCE=',F8.4)
  489 FORMAT (' ',11X,'SNOW BALANCE= ',F8.4)
  460 FORMAT ('0',8X,'WATER, MILLIMETERS')
C
C                               NUTRIENT FORMATS
C
 4000  FORMAT ('0','NUTRIENTS - ',A3,11X,'ORG-N',3X,'NH4-S',3X,'NH4-A',
     1          3X,'NO3+NO2',4X,'N2',2X,'PLNT-N',3X,'ORG-P',3X,
     2          'PO4-S',3X,'PO4-A',2X,'PLNT-P',6X,'CL')
 4005  FORMAT  ('0',3X,'STORAGE')
```

```
4006  FORMAT  ('0',9X,'SURFACE LAYER',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4007  FORMAT  ('0',9X,'UPPER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4008  FORMAT  ('0',9X,'LOWER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4009  FORMAT  ('0',9X,'GROUNDWATER',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4011  FORMAT  ('0',3X,'REMOVAL')
4012  FORMAT  ('0',6X,'ADVECTIVE')
4013  FORMAT  ('0',9X,'SEDIMENT',8X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4014  FORMAT  ('0',9X,'OVERLAND FLOW',3X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4015  FORMAT  ('0',9X,'INTERFLOW',7X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4016  FORMAT  ('0',9X,'TOTAL TO STREAM ',F8.2,5F8.3,F8.2,3F8.3,F8.3)
4017  FORMAT  ('0',9X,'PERCOLATION TO '/,' ',12X, 'GROUNDWATER',2X,
     1         F8.2,5F8.3,F8.2,3F8.3,F8.3)
4018  FORMAT  ('0',6X,'BIOLOGICAL - TOTAL ',F8.2,5F8.3,F8.2,3F8.3,F8.3,
     1        /,' ',9X,'SURFACE',9X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     2        /,' ',9X,'UPPER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     3        /,' ',9X,'LOWER ZONE',6X,F8.2,5F8.3,F8.2,3F8.3,F8.3,
     4        /,' ',9X,'GROUNDWATER',5X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4019  FORMAT  ('0',6X,'HARVEST',12X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
4021  FORMAT  ('0',3X,'MASS BALANCE',
     1        /,' ',6X,'NITROGEN   = ',F8.3,
     2        /,' ',6X,'PHOSPHORUS = ',F8.3,
     3        /,' ',6X,'CHLORIDE   = ',F8.3)
4030  FORMAT (' ',12X,'BLOCK',I2,6X,F8.2,5F8.3,F8.2,3F8.3,F8.3)
C
      END
//LKED.SYSLMOD DD DSN=WYL.X2.A19.HD7508.ARMLM.DP100677,DISP=(NEW,KEEP),
//  UNIT=DISK,SPACE=(TRK,(30,2,2),RLSE),VOL=SER=PUB005
//LKED.SYSIN DD *
 NAME ARM
/*
```